California

School IPM

Model Program **Guidebook**

2nd Edition

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This document and any updates may be downloaded at www.schoolipm.info.

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Acknowledgements

This guidebook evolved out of requirements from the Healthy Schools Act (Chapter 718, Statutes of 2000). The Department of Pesticide Regulation gathered ideas from surveying school districts (Tootelian, 2001), and discussions with its School IPM Advisory Group (See www.schoolipm.info for a list of advisory group members).

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Flex your POWER[SM]

Dear IPM Coordinator and School District Staff:

This letter introduces you to the California School IPM model program guidebook. Please review this guidebook and use it as a reference tool as you implement integrated pest management (IPM) in your school district.

Who Developed This Guidebook?

The California Department of Pesticide Regulation (DPR) developed this model program guidebook, as required by the Healthy Schools Act of 2000, for use by school districts that wish to adopt a least-hazardous IPM program. The authors drew their information from federal school IPM guidelines, other states' IPM programs, California state laws and regulations, the University of California Statewide IPM program, California school districts that have already implemented IPM programs, the pest control industry, and public interest groups.

What Is the Purpose of the Guidebook?

This guidebook is designed to help you use IPM in your school's pest management program. The guidebook serves as a guide and provides models for schools that choose to implement IPM. IPM is not required in California schools. We intend this guidebook to be useful as both a companion manual for the DPR California School IPM coordinator training and as a reference tool for your school district when implementing IPM. IPM coordinators can use this text to train school district personnel in IPM theory and practices. School staff can refer to it for day-to-day pest management questions.

Why Use the Guidebook?

Whether you are just starting to implement an IPM program or want to improve an existing program, this guidebook will serve as a useful resource to answer your IPM questions and to provide practical, hands-on steps that can be implemented as part of your IPM program. The first part of this book lays out the essential elements of a least-hazardous IPM program and the steps to adopting an IPM program. Specific strategies for pest management indoors and outdoors are covered in the second part of the guidebook, arranged by individual pests.

We hope you find this guidebook to be useful and we encourage your input into the next edition. Please contact Belinda Messenger at bmessenger@cdpr.ca.gov or 916-324-4077 with your suggestions.

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SECTION 1

Introduction to California School IPM

1.1 What is Integrated Pest Management (IPM)?

Integrated pest management (IPM) is an approach to pest control that uses regular monitoring and recordkeeping to determine if and when treatments are needed. It employs a combination of strategies and practices to keep pest numbers low enough to prevent unacceptable annoyance or damage. IPM does not eliminate the use of chemical pesticides, but instead uses them only when needed. There are many definitions of IPM; the Healthy Schools Act of 2000 (Food and Agricultural Code section 13181) defines IPM as:

> "...a pest management strategy that focuses on long-term prevention or suppression of pest problems through a combination of techniques such as monitoring for pest presence and establishing treatment threshold levels, using non-chemical practices to make the habitat less conducive to pest development, improving sanitation, and employing mechanical and physical controls. Pesticides that pose the least possible hazard and are effective in a manner that minimizes risks to people, property and the environment, are used only after careful monitoring indicates that they are needed according to pre-established guidelines and treatment thresholds."

At its most basic, IPM is a common-sense pest management approach that requires pest management action only when necessary and with the least-hazardous method. Many pest management methods, such as biological, cultural, physical, educational, and chemical methods, can be used in a least-hazardous IPM program. Educational methods are used to enhance pest prevention, and to build support for the IPM program. Chemical controls are used only when needed, and in the least-hazardous formulation that is effective against the pest.

Pest prevention begins with correct identification of the pest and knowledge of its needs and entry points. Available food, water, hiding places and entry points must be eliminated for long-term suppression of a pest. Use of least-hazardous IPM has been shown to dramatically reduce the use of chemical pesticides, while providing better, longer-lasting control of pests.

Box 1-1: What is a pesticide?

A pesticide is any substance intended to control, destroy, repel or attract a pest. Some common pesticide types include herbicides (for control of weeds and other plants), insecticides (for control of insects), disinfectants and sanitizers (to control disease-causing microorganisms on inanimate objects) and rodenticides (for control of rats, mice and other rodents).

Box 1-2: Principles of IPM

1. Perform thorough in-field or on-site assessments of each pest problem.
2. Establish scouting or inspection procedures to monitor pest population levels and severity of the pest problem.
3. Use appropriate control action thresholds, if available, for each (combination of) pest problem(s) to determine when corrective action(s) must be implemented.
4. Determine corrective action(s) when a control action threshold is reached. Use the following objectives in the selection of specific reduced-risk practices: least disruptive of natural controls, least hazardous to human health, least toxic to non-target organisms, least damaging to the environment, most likely to produce a permanent reduction in the supportive environment for the target pest(s), and most cost-effective considering both short- and long-term objectives.
5. Establish and maintain an accurate record-keeping system to catalog monitoring information and document management procedures.
6. Evaluate the effectiveness of the IPM program and make adjustments as needed.

1.2 Why implement an IPM program?

IPM is an accepted method of pest management in schools (Stauffer et al., 1998; Grant and Woodsen, 2001). Using least-hazardous IPM techniques can save time, money and energy, as well as decrease the use of pesticides. In a 2002 California Department of Pesticide Regulation (DPR) survey of California school districts, 53% of the respondents stated that IPM reduced or had no impact on cost (Geiger and Tootelian, 2002). IPM practitioners prevent pest problems by eliminating the conditions that allow pests to flourish, detecting pests early before the population grows, and by establishing records so that outbreaks can be predicted. Other school concerns, such as sanitation, maintenance and energy usage can be addressed with proper IPM practices.

Using fewer pesticides in an IPM approach addresses the growing concern for the health and safety of schoolchildren and other building occupants. Many parents, community organizations and advocacy groups have become more aware, and more cautious, of pesticide use around children. A desire to know that schools are using pesticides safely and judiciously has been expressed to legislators all over the United States and as a result, laws concerning pesticide use in schools are in place in several states including California.

1.3 What is DPR's role in California school IPM?

In 1993, DPR began a pilot program to work with interested school districts to provide them information about IPM practices and assist them in developing an IPM program. DPR also conducted an extensive survey of school districts in 1996 to gain information about their IPM policies and practices (Simmons et al., 1996). Governor Davis felt that IPM in schools was important enough to add a school IPM program to DPR's budget in July 2000, as part of his Children's Health Initiative. Governor Davis later signed Assembly Bill 2260 (the Healthy Schools Act of 2000, Education Code sections 17608–17613 and Food and Agricultural Code sections 13180–13188) into law on September 25, 2000. This law, authored by Assembly Member Kevin Shelley, puts into code DPR's existing voluntary school IPM program and added some new requirements regarding pesticides, such as notification, posting, and recordkeeping for schools, and enhanced pesticide use reporting. The Healthy Schools Act makes IPM the preferred pest management method in California schools. Most provisions of the law took effect January 1, 2001.

Through its school IPM program, DPR is committed to facilitating voluntary establishment of IPM policies and programs in schools throughout California, while assisting school districts with implementation of the new Education Code requirements. DPR also works with other boards and departments of the California Environmental Protection Agency and with the California Department of Education to tie IPM into related areas such as school gardens and environmental education.

How is DPR helping school districts?

1.3.1 DPR's School IPM Advisory Group

In 2000, DPR created a School IPM Advisory Group, consisting of representatives from 31 key school organizations and other interested stakeholders. This group meets to advise DPR about School IPM program elements. The advisory group's recommendations are helpful in ensuring that the program achieves its goals. See the DPR School IPM Web site at www.schoolipm.info for the current list of School IPM Advisory Group members.

1.3.2 DPR's School IPM Web Site

DPR has established an IPM in Schools Web site at www.schoolipm.info as a source of information on school IPM. The site includes home pages customized for parents/teachers, school administrators, maintenance and operations staff, and pest management contractors. Resources available include summaries of the Healthy Schools Act, frequently asked questions, new regulations on school pesticide use reporting, an exhaustive listing of pest prevention techniques, sample notification letters to parents about expected pesticide use, a worksheet to determine whether specific pesticide products are exempt from HSA requirements, and many other items. The Web site also allows school districts to compare the health and environmental impacts of management practices used for specific pests, and to identify the active ingredients associated with pesticide products schools may use. In addition, the Web site provides extensive links to other IPM resources.

1.3.3 School IPM Training

The Healthy Schools Act directs school districts to designate individuals (sometimes known as IPM coordinators) to carry out requirements of this law. DPR offers voluntary train-the-trainer programs so that those who carry out the IPM program understand principles of IPM and can train their staff. DPR also supports regional workshops that showcase model IPM programs and provide hands-on experience.

1.3.4 Assisting Districts to Establish IPM Policies and Programs

Some school districts already are working with DPR to establish IPM programs. Currently, DPR is working with California Department of Education and has information on its Web site about model programs. In addition, DPR publicizes its school IPM program at meetings attended by maintenance and operations directors and their staff, school administrators, educators, and parents.

1.3.5 School IPM Guidebook

This guidebook is the result of an effort to tailor an existing school IPM guidebook to conditions in California. The Healthy Schools Act requires DPR to include specified IPM program elements. These program elements are covered in Part 1.

1.3.6 Evaluating IPM Adoption in Schools

Baseline and follow-up surveys help DPR to measure IPM adoption in schools, to evaluate what kind of outreach school districts need, and to see whether this outreach has been effective.

1.3.7 Pesticide Use Reporting Form

The Healthy Schools Act requires DPR to prepare a school pesticide use reporting form to be used by licensed pest control businesses when they apply any pesticides at a school. Licensed pest control businesses must submit the form to DPR at least annually. This form can be downloaded from the DPR School IPM Web site at www.schoolipm.info or call 916-324-4100.

1.4 What are the requirements of the Healthy Schools Act for school districts?

All public school districts are required to comply with the Healthy Schools Act. These requirements include annual written notification with specified information on pesticides to all school staff and parents or guardians of students; the opportunity for interested staff and parents to register with the school district if they want to be notified of individual pesticide applications at the school before they occur; posted warning signs at each area of the school where pesticides will be applied and records kept of all pesticide use at the school for four years. Sample letters and posting signs are included in **Appendix A** to help schools comply with these requirements.

1.4.1 Notification (Education Code section 17612(a))

Each school district is required to "annually provide to all staff and parents or guardians of pupils enrolled at a schoolsite a written notification of the name of all pesticide products expected to be applied at the school facility during the upcoming year." This notification must include the active ingredient(s) in each pesticide product and the Internet address used to access information on pesticides and pesticide use reduction strategies developed by the DPR (pursuant to section 13184 of the Food and Agricultural Code). The notification may contain other information deemed necessary by the school district. Adding information about the target pest and the application method can be helpful to parents or staff unfamiliar with pests and pesticides, although this is not required by the Healthy Schools Act.

Recipients of the annual pesticide notice may register with the school district if they wish to receive notification of individual pesticide applications at the school facility. People who register for such notification must be notified of individual pesticide applications at least 72 hours before the application. This notice shall include the product name, the active ingredient or ingredients in the product, and the intended date of application. If a pesticide product is not included in the annual notification but is later intended for use at the school site, the school district must provide written notification of its proposed use at least 72 hours before application.

These notification requirements are intended to be inexpensive for school districts. Annual notification to parents and guardians may be included as part of any other written communication provided to individual parents or guardians. Registrants can be notified by U.S. mail, e-mail or telephone. Notice through first-class mail is not required. If districts contract for monthly or periodic pest management services, people on the registry may be notified of each pesticide application by the contractor, if this is agreed to as part of the contract.

The notification procedures described above are not required for pest control measures taken during an emergency condition, but the school district shall make every effort to provide the required notification for an application of a pesticide under emergency conditions.

1.4.2 Posting (Education Code section 17612(d))

School districts are required to post a warning sign in each area of a school site where pesticides will be applied. The sign must prominently display the term "Warning/Pesticide Treated Area," and will include "the product name, manufacturer's name, the United States Environmental Protection Agency's product registration number, intended date and areas of application, and reason for the pesticide application."

The warning sign must be visible to everyone entering the treated area and must be posted 24 hours prior to the application and remain posted until 72 hours after the application. One option is to silk screen the text onto metal signs with blanks for the product name, manufacturer's name and other information. Specifics of each application can then be filled in with a grease pencil.

1.4.3 Exemptions to Notification and Posting Requirements

The requirements for notification and posting change in a pest control emergency. See section 4.2 of this guidebook, under "Declaring an Emergency Under the Healthy Schools Act," for more details. "Emergency conditions" are defined in the law as "circumstances in which the school district designee deems that the immediate use of a pesticide is necessary to protect the health and safety of pupils, staff and other persons, or the school site." (Education Code section 17608[c]) In an emergency, staff, parents and guardians need not be notified 72 hours in advance; however, every effort must be made to provide the notification. The warning sign must be posted immediately upon an emergency application and remain posted until 72 hours after the application. (Education Code section 17612.2(c))

Pesticides used in an emergency should pose the least possible hazard to people, property, and the environment, and be used only after the emergency has been documented (including type of problem, associated risks and pest management alternatives considered but not used). Pesticide products selected for use must be registered with DPR to control the pest and be effective for the intended purpose.

The Education Code (section 17610.5) notification and posting requirements described above do not apply to "a pesticide product deployed in the form of a self-contained bait or trap, to gel or paste deployed as a crack and crevice treatment, to any pesticide exempted from regulation by the United States Environmental Protection Agency pursuant to the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. Sec. 25 (b)), or to antimicrobial pesticides, including sanitizers and disinfectants." (For more information on exempt pesticides, see DPR's School IPM Web site at www.schoolipm.info or **Appendix B**).

Box 1-3 Where to find a copy of the Healthy Schools Act

A copy of the Healthy Schools Act, Assembly Bill 2260 (Chapter 718, Statutes of 2000) is in Appendix D, or an electronic copy is available at www.schoolipm.info.

The notification and posting requirements do not apply to schools operated by the California Youth Authority. The Healthy Schools Act however does require that "the school administrator of a school operated by the California Youth Authority shall notify the chief medical officer of that facility at least 72 hours prior to application of pesticides. The chief medical officer shall take any steps necessary to protect the health of pupils in that facility." (Education Code section 17612.2 (e)) See **Appendix C** and **Appendix D** for more details.

The notification and posting requirements described above do not apply to activities by participants in the state program of agricultural vocational education. School farms are regulated by another set of posting and notification requirements. (California Code of Regulations 6618) The notification and posting requirements do not apply to agencies that have a cooperative agreement with the State Department of Health Services. (Education Code section 17631)

1.4.4 Other Requirements for Schools

In addition to the activities outlined above, the law adds certain requirements to the Education Code (sections 17608–17613) to be implemented by all California schools:

Each school shall maintain records of all pesticide use at the school for four years and make the records available to the public upon request. Records can be computerized but paper copies kept in a file provide easy access. Records can simply be a copy of the posted warning sign with the amount of the pesticide used noted on the copy.

Each school district shall designate an individual (who may be the IPM coordinator) to carry out the requirements of the Healthy Schools Act, outlined above.

To assist school districts, DPR has posted on its Web site samples of the annual notification and the register, and a template of the warning sign. These documents can be downloaded at www.schoolipm.info. These forms are included in **Appendix A**.

1.5 What are the Healthy Schools Act requirements for licensed pest control businesses?

This law (Food and Agricultural Code section 13186) requires that:

Licensed pest control businesses shall report pesticide applications by school annually to the Director of DPR beginning with applications made on or after January 1, 2002. A downloadable copy of the Pesticide Use Reporting form for School Sites can be found in the laws and regulations section at www.schoolipm.info or call 916-324-4100.

SECTION 2

Adopting an IPM Program

One of the characteristics of an IPM approach that makes it so effective is that the basic decision-making process is the same for any pest problem in any location. The strategies and practices may change, but the steps taken to decide when action is needed, and which methods are appropriate, are the same each time. Thus, the pest manager does not need to memorize reams of pest control "recipes" for specific pests. Instead, it is an understanding of the components of an IPM program that must be mastered.

BOX 2-1: Components of an IPM program

Technical components include:

- Pest monitoring.
- Pest identification.
- Determining injury and action levels that trigger treatments.
- Timing treatments to the best advantage.
- Spot-treating the pest (in order to minimize human and other non-target organism exposure to pesticides).
- Selecting the least-disruptive practices.

Administrative components include:

- Adopting an IPM policy.
- Establishing a recordkeeping system.
- Evaluating the effectiveness of treatments to finetune future actions.
- Educating all people involved with the pest problem and with efforts for resolution.

Each of these components is discussed in detail in later sections of this manual.

2.1 How to Develop an IPM Program

There are key components to the development of an IPM program. The adoption of an IPM policy by school administration is the most important, followed by educating key decision-makers about the need for the program and identifying the roles and responsibilities of the various members of the school community. IPM operations involve designing and implementing IPM programs for specific pests; training the pest management, custodial, grounds maintenance, and nursing staff in IPM methods; and institutionalizing the IPM program.

2.1.1 Adopting an IPM Policy

The first step towards implementation of an IPM program is the adoption of an IPM policy by the school board. See section 2.2 on "Developing an IPM Policy Statement for School Pest Management". A model school IPM policy and some California school IPM policies are provided in **Appendix E**.

2.1.2 Educating Key Decision-Makers

The key to a successful program is education of the school board, superintendent, business operations manager, principals, PTA officers, and other decision-makers about benefits from adopting an IPM approach.

Box 2-2: Identifying Pest Management Roles*

In successful school IPM programs, students, staff, parents, pest managers, and decision-makers all have important roles. These functions and responsibilities are identified below.

Students and Staff—The Occupants

Students and staff play major roles in keeping the school clean. Sanitation should not be viewed as only the custodian's job. If students and staff learn the connection between food, garbage and pests such as cockroaches, ants, flies, and rodents, they are more likely to take san-itation measures seriously and comply with them.

The Pest Manager/IPM Coordinator

The pest manager (often called the IPM coordinator) is the person who observes and evaluates the site (or directs others to do so) and decides what needs to be done to achieve the pest management objectives. This person is often the school site designee who is responsible for complying with the requirements of the Healthy Schools Act. The pest manager designs the IPM program and keeps accurate records of the amount and location of all treatments.

Decision-Makers

Generally, people who authorize the IPM program and control the funding for the pest management program are people involved in the school administration, such as a superintendent or assistant superintendent of schools. However, a person indirectly involved with the site may become a pest management decision-maker, e.g., the Health Department inspector. On other occasions, the purchasing agent or contracting officer for a school system or district may be a major decision-maker for a school site. Decision-makers also determine if the pest manager is performing at an acceptable level and if the pest management objectives are being met. Decision-makers must also provide the necessary level of financial commitment for any IPM program to succeed.

*Adapted from U.S. EPA, 1993

2.1.3 Identifying Pest Management Roles and Responsibilities

It is critical to have the support of representatives from all segments of the school community and that they be involved from the beginning in setting up the IPM program. This includes school board members, administrators and their staff, teachers, students, parents, custodians, food service workers, ground maintenance personnel, school nurses, and pest control professionals. When the respective pest management roles of those involved directly or indirectly with pests in the school system are identified and agreed upon, and when these people communicate well with each other, an effective IPM program can progress. A discussion of pest management roles and responsibilities is provided in **Box 2-2**.

2.2 Developing an IPM Policy Statement for School Pest Management

Schools need a clear policy statement to secure agreement about how pest control will be performed. The policy statement should include a statement of pest management goals, a set of roles and responsibilities for occupants, pest management personnel and key decision makers, and a set of pest management guidelines.

Districts develop and adopt written policies on many topics, including pest management, and make them available to all interested persons. Policies serve as direction for the operation and successful and efficient functioning of the district's schools. The Board policies provide direction to the district. Policies include the general goals and acceptable procedures for the school district. District policies are framed in terms of state laws and regulations and other

Box 2-3: Tips for Starting an IPM Program

The following suggestions can help overcome barriers and smooth the transition to IPM implementation.

Require staff training in IPM. When writing the IPM policy document, include a requirement for the continuing education of pest management personnel. Ensure that budgetary allocations are made to assist them in obtaining the information, skills, and equipment they need to carry out the policy.

Start small. Begin IPM implementation in one location (e.g., a kitchen in a single school or a section of lawn at a single school) and include short-term objectives. For example, when dealing with a number of pest problems, identify one of the pests likely to respond quickly to an IPM approach, such as cockroaches, so a short-term objective can be realized. Test the IPM practices and fine-tune them. When the program is working successfully in one area, or against one pest, expand the program further.

Develop a list of resources. Know where information is available when needed, and know when to seek outside help. County Cooperative Extension personnel, teaching staff in the biology or entomology departments of a nearby university, staff at the local zoo, and even the high school biology teacher can help identify pests and their natural enemies. Ask these people if they know of experts in the particular pest problem. Gradually compile a list of people to call for advice.

Appendix G can be the beginning of a resource list.

Always post the telephone number for the local poison control center in a prominent place.

Build a library for pest management personnel, staff, and students to use. Cooperative Extension publications are usually free or inexpensive and can be good sources of information on pest biology. Even though these publications do not always recommend the least-hazardous approach, they are still useful. The recommended reading section of this manual, **Appendix H**, lists many useful books.

Don't change everything at once. To the degree possible, retain communication and accountability procedures already in use. Tailor new recordkeeping and reporting forms to fit existing agency formats.

Recycle existing equipment to uses consistent with IPM methods rather than immediately eliminating the equipment.

Share the process. Involve members of the student body and staff, especially pest management personnel, in the day-to-day IPM program process as early as possible so they will understand and support the program during the sometimes-difficult transition period.

Emphasize communication and plan for future training. During the IPM transition period, keep all personnel informed about what is planned, what is currently happening, the expected outcome, and what will happen next. Prepare written records and visual aids that will remain in the school when persons associated with development of the IPM program are no longer there.

Publicize the program. Develop good rapport with district public relations personnel and with the local news media. For interviews and photo sessions, include pest managers, custodians, and landscape maintenance personnel as well as principals, school board members, and the superintendent.

Involve the community. Form an IPM advisory committee (see section 2.4 for more information) composed of interested parents, school staff, community organizations, health specialists, and pest control professionals. They can help make IPM implementation a budgetary priority in the district, and can donate or locate resources that may not otherwise be available to the school.

*Adapted from Flint et al., 1991

regulatory agencies within state and federal levels of government.

The district also develops written administrative regulations and procedures, when such are required, to carry out the provisions of policies adopted by the board.

The California School Boards Association (CSBA) (http://www.csba.org) develops and provides sample policies and administrative regulations for its members, which include most of the school districts in the state. Contact CSBA to see the CSBA Sample Board Policy Business and Noninstructional Operations Environmental Safety (BP 3514(a)) and CSBA Sample Administrative Regulation Business and Noninstructional Operations Integrated Pest Management (AR 3514.2(a)), which include provisions and procedures that fulfill the requirements of the Healthy Schools Act.

See **Appendix E** for a model policy and examples of school board policies and administrative regulations from several Californian school districts.

2.3 IPM Operations

The operation of an IPM program involves designing IPM programs for specific sites and pests, delivering IPM services, and evaluating program costs. Fully developed, multi-tactic IPM programs are generally implemented in three stages, although components of each stage often overlap.

Monitoring and pest action thresholds should take the place of routine pesticide applications, and preliminary pest management objectives should be developed.

Box 2-3 outlines tips for getting programs started. The initial IPM program focuses primarily on moving away from routine use of pesticides by instituting a pest monitoring program to collect data and establish pest treatment (action) thresholds based on pest population levels (see sections 3 and 4 in part 1).- A pilot program can be initiated at one school site, so new skills can be gained and techniques fine-tuned before the program is expanded throughout the system. Pesticides may remain the primary control agents used during this stage, but applications are made only when pest numbers reach action levels. Spot treatments rather than area-wide applications are stressed, nonvolatile baits and dusts are substituted for vaporizing sprays, and less hazardous soaps, oils, and microbial materials replace compounds that are more hazardous. At the same time, a planning process is established to set pest management objectives, identify the fundamental causes of pest problems in the school system, and assess methods to address these causes with primarily non-chemical solutions.

Pest management plans are formalized as a program becomes more mature. A concerted effort to maximize pest proofing, non-chemical pest suppression and education should be made as well as incorporating physical, mechanical, biological, and educational strategies and practices into the pest management program. Most pests found in school buildings can be attributed to faulty building design, lack of structural repairs, accumulation of clutter and paper, poor food handling and poor waste management practices. To achieve permanent solutions to pest problems, pest management staff must devote time to educating building maintenance and custodial staff, food handlers, and teachers and students about their role in attracting or sustaining pests, and enlisting their participation in solving the problems.

A similar process is needed to solve outdoor pest problems. For example, pest managers need cooperation from physical education and coaching staff to reduce stress on athletic turf that leads to weed problems. Landscape maintenance staff need encouragement to locate pest-resistant plant materials, increase diversity in the plantings to attract natural enemies of pests, and experiment with non-chemical pest control methods. Assistance from playground supervisors is needed to insure that food debris and other wastes are placed inside waste receptacles where pests such as rats and yellow jackets cannot gain access to them.

The primary activities during this stage include developing site-specific pest management plans and educating all participants about their roles and responsibilities in helping to implement the IPM plans.

2.3.1 Developing Site-Specific Pest Management Plans

Written plans help move school pest control from a reactive system to a prevention-oriented system. Annual plans enable pest managers to prioritize use of resources, justify planned expenditures, provide accountability to IPM policies, and coordinate with other components of the school system. These plans emphasize repairing buildings, changing waste management procedures to deny food, water, and shelter to indoor pests, and modifying plant materials and landscape maintenance practices to relieve plant stress and improve plant health.

Costs of these repairs and changes may fall within ongoing operating expenses in existing budgets, or may require a one-time expenditure. In the long-term, however, these activities will reduce overall pest control costs as well as other maintenance and operating budget expenses.

2.3.2 Educating Participants

Food service and custodial staff, clerical and administrative staff, teaching staff, and students must be educated about their role in reducing pest presence and the necessity of a cooperative effort to control a pest.

Everyone must understand the basic concepts of IPM, who to contact with questions or problems, and their role in the program. Specific instructions should be provided on what to do and what not to do.

Teachers and other staff should be notified that applying pesticides (except those pesticides exempt from Healthy School Act requirements in **Appendix B,** such as baits) on school sites falls under the Healthy Schools Act and must meet all posting, notification and record-keeping requirements. They should be provided with clear instructions on how and to whom to report a pest problem, rather than attempting to control the pest themselves. One option is to provide teachers and others with "pest alert" cards on which they can write the date, location, and pest problem. The card can be returned to the teacher with a notation of what was (or will be) done about the problem and what, if any, assistance is requested of the teacher and students (e.g., better sanitation in the classroom).

If information on IPM can be woven into the current curriculum, students and teachers will better understand their roles and responsibilities in the program, but more than this, students will carry these concepts into their adult lives. The following ideas are just a few of the ways that this information can be included in the school curriculum:

- Involve science classes in identifying pests and beneficial insects, and in researching IPM strategies.
- Involve art classes and English classes in developing simple fact sheets and other educational materials on various school pests. Use information from the individual pest management sections in this manual.
- Involve vocational classes in making site plans of the school to use for monitoring, site inspections for structural defects that may exacerbate pest problems, and suggestions for structural modifications to eliminate the problems.
- Involve journalism classes in reporting on the new IPM program.
- Use some of the innovative curricula available that emphasize IPM (see **Appendix F** for a list).

A mature IPM program may become institutionalized. This includes developing ongoing incentives and reward systems for achieving IPM objectives, establishing an IPM library of educational materials and staff training programs, and writing operations manuals that describe IPM policies and procedures to be followed by pest management personnel.

2.3.3 Develop Incentives and Rewards

Involve staff in establishing benchmark objectives (e.g., 20% pesticide reduction the first year, testing of boric acid in wall voids in place of broadcast spraying for cockroaches, raising of mowing height on turf to shade out weeds).

Reward staff for innovations and for achieving objectives (e.g., a letter of commendation, recognition at a staff awards picnic, article in local news media, travel authorization to an out-of-town IPM conference.).

Provide IPM educational materials and staff training programs.

IPM programs are information-intensive rather than treatment-intensive. This necessitates motivating pest control staff to try new approaches and broaden their professional skills.

Build an IPM library of literature and training videos, and provide time for staff to attend training seminars or take courses in pest identification.

2.3.4 Prepare an IPM Operations Manual

Written policies and procedures are needed to insure clarity about responsibilities, authorized activities, permitted materials, and other program elements. A manual serves as an accountability mechanism, and helps insure program continuity despite personnel changes. A loose-leaf binder that allows for addition or deletion of materials over the years is a convenient format. In addition to official policies and procurement practices, the manual should specify the following:

- Pest management objectives.
- The overall IPM process for managing each pest.
- Biological and ecological information on the pest and its natural enemies.
- The monitoring system for each pest (and natural enemies when appropriate).
- Injury levels (i.e., damage by pests) and action thresholds for pests.
- The method of recordkeeping system to be used (e.g., paper or electronic).

- How to interpret field data.
- How to obtain, use, and maintain equipment and supplies required to carry out monitoring and treatment activities.
- The range of treatment practices authorized for use against the pest and how to employ them.
- A list of pesticides authorized for use in the district and the Material Safety Data Sheet (MSDS) for each pesticide.
- Safety procedures and resources for emergencies.
- How to evaluate treatment effectiveness.

2.3.5 Building Support for the IPM Program

Once an IPM policy has been adopted by a school board, implementation is usually the responsibility of the IPM coordinator, who will instruct the in-house pest control staff or outside contractors (see section 2.7 on contracting for pest management services and **Appendix I** for sample IPM contract specifications).

Change never comes easily, and a number of predictable obstacles may exist within a school system—both psychological and institutional—to be overcome when initiating IPM programs. At the same time, even if the public has been involved with development of a policy, there are likely to be occasional complaints and controversies, especially as pests, pest control practices, and public concerns change.

For more information on how to develop a program and how to overcome barriers to adoption, read the UC IPM Publication 12 "Establishing Integrated Pest Management Policies and Programs: A Guide for Public Agencies" (see **Appendix J**).

2.4 Community-Based School District Advisory Committee

Many school districts have established an IPM advisory committee to assist with developing and implementing the district's pest management policy. This committee can be very useful in making suggestions, doing research, and bringing in new information, but it need not have authority to make policy. It is helpful if the committee also has an independent pest management expert (preferably one trained in IPM). This group can be a valuable resource for tracking and evaluating the progress of the IPM program in meeting the district-wide pest management goals. Involving diverse representatives of the community in policy development is a good way to draw together vast support for the policy and program later. Periodic reevaluation and advice of the committee on implementation will be very helpful to ensure that the district's IPM goals and objectives are achieved while providing the best support possible for constituent groups within the district. The committee can help make IPM implementation a budgetary priority in the district, and can donate or locate resources that may not otherwise be available to the district.

Ideally the advisory committee should include concerned parents, school administrators, faculty, staff, pest control operators, maintenance and operations staff, other professionals with pest management experience, physicians with toxicological expertise, environmental organizations, health advocates, interested organizations, and other members of the community.

The committee should meet at least once each year. Regularly scheduled IPM committee meetings are necessary to monitor and evaluate progress, correct inefficient procedures that hinder meeting the stated goals of the school IPM policy statement, and educate concerned individuals involved with the program.

2.5 Community-Based Standard for Notification and Posting

More stringent standards for notification and posting than those required by the Healthy Schools Act can be recommended by stakeholders such as the community-based advisory committee, the IPM coordinator, interested parents or the School Board. The law states that each area of the schoolsite where pesticides will be applied must be posted. It does not, for instance, specify how many signs are required or exactly where those signs should be placed. The law also does not describe exactly how parents are to be notified of pesticide applications. The stakeholders mentioned above may develop and recommend more detailed procedures to the School Board regarding posting or notification of pesticide applications.

2.6 Selecting and Training an IPM Coordinator

2.6.1 Healthy Schools Act Responsibilities of the IPM Coordinator

Under the Healthy Schools Act of 2000, Education Code section 17609(d), each school district is required to appoint a "school designee" who is responsible for carrying out the requirements of the Healthy Schools Act at the schools within the district. These duties include notification, posting and recordkeeping. See section 1.4 for the requirements of the Healthy Schools Act. If the school district decides to implement an IPM program, the school designee may be known as the IPM coordinator. Often the director of maintenance and operations is chosen as the designee or IPM coordinator. For districts where the IPM coordinator is not experienced in least-hazardous IPM, a professional IPM consultant may be hired to assist in implementing a least-hazardous IPM program.

2.6.2 Other Responsibilities of the IPM Coordinator Within an IPM Program

The IPM coordinator will acquire a number of responsibilities, some of which are not directly related to pesticide applications. The school district must ensure that the IPM coordinator is trained in least-hazardous IPM concepts and methods, as defined by the Healthy Schools Act. The IPM coordinator's duties may include some or all of the following:

- Serving as a primary contact for pest control matters and coordinating all pest control decisions for the school district.
- Leading the development and implementation of an IPM policy and program.
- Scheduling and facilitating pest management advisory committee meetings.
- Monitoring pest problems or areas where pest problems may occur (see section 3).
- Recording monitoring data.
- Setting pest management action levels.
- Recording all pest sightings by school staff and students.
- Facilitating communication about pest management among all personnel levels in the district.
- Having school pests accurately identified

(this can be accomplished with the aid of the County Department of Agriculture, University of California Cooperative Extension, and the entomology or botany departments of local universities or community colleges, see also **Appendix K**, How to Collect and Preserve Specimens for Identification.).

- Devising IPM plans for school pests.
- Making decisions about appropriate pest management actions.
- Recording all pesticide use and other pest management actions.
- Evaluating the effectiveness of pest management procedures and revising IPM plans accordingly.
- Ensuring the completion of work orders for structural repairs and housekeeping and sanitation measures intended to reduce or prevent pest problems.
- Training staff in IPM practices and researching staff training opportunities.
- Coordinating with principals and district administration to carry out the education and IPM training provisions of the district's IPM policy.
- Coordinating the collection and dissemination of current information on pest management and pesticides or pest-related health and safety issues to staff and faculty.
- Overseeing pest management contractors.
- Informing contractors of the district's IPM policy and pest management procedures.
- Assuring that all of the contractor's recommendations on maintenance and sanitation are carried out where feasible.
- Ensuring that pest management implications are considered when planning new construction or site modifications.
- Meeting with the press and/or community groups about pest management issues.

An individual selected to be a school IPM coordinator must be knowledgeable in many areas. The school district should ensure that the IPM coordinator is trained in IPM concepts and methods. The IPM coordinator must be conversant in the following:

- The nature and benefits of IPM.
- IPM policy implementation.
- Components critical for success of an IPM program.
- Recordkeeping, notification, posting requirements pursuant to the Healthy Schools Act.
- Pest control measures including prevention, and mechanical, cultural, biological and chemical controls.
- Pest identification and reporting.
- Monitoring and inspection for pest problems.
- Program evaluation and quality control.
- Communication and interaction with the school community.
- Communication with mass media, the community, and parents.
- Community outreach and interaction.
- Liability issues in pest management and the operation of schools.
- Bids and contracts.
- Pesticide Safety Information Series leaflets, published by DPR.

2.7 IPM Contract Performance Specifications

Integrated pest management conducted by professionals should lead to a safe school free from significant pest problems and potentially harmful pesticide residues. Hiring a professional service to conduct pest management relieves the school district from the responsibility of having trained staff, storing potentially harmful chemicals, and continually maintaining a set of complex records. However, hiring a professional service does not exclude the importance of communication, follow through, and making sure that the contracting process achieves the desired result. This includes hiring a pest management company that is truly service-based and experienced in least-hazardous integrated pest management.

There are several categories of pest management services available for hire, primarily general pest control (indoors and around the perimeter of a structure), termite inspection and control, vertebrate pest control (birds and mammals such as skunks, ground squirrels, and feral dogs and cats), and weed management. There are also IPM consultants that schools can contract with to help develop an IPM plan, educate school personnel and evaluate pest control contractors. Clearly, not all companies offer the same range of service. More often than not, companies and usually the smaller companies are not licensed in both agricultural and non-agricultural categories. Companies licensed by the structural pest control board usually do termite management, general pest management, and some vertebrate pest management (rats, mice, and some birds). Companies licensed by DPR generally do weed management and some vertebrate pest management. Finally, DPR licenses companies that do maintenance gardening and some insect and weed management. Note that when it comes to mold in buildings, different licenses are required. Consideration should be given to what is likely to be encountered in the task. For example, assume mold is the problem to be remedied, but in the process of reconstruction, dry rot is found. Does the process stop because the company is not licensed to handle dry rot (which is under the jurisdiction of the Structural Pest Control Board) or can the company handle both types of problems? The pest manager must determine whether the contractor is qualified to handle both problems.

2.7.1 In-House or Contracted Services?

IPM programs can be successfully implemented by "in-house" school employees or by contracting with a pest control company. A combination of in-house and contracted functions may also suit the needs and capabilities of the school system. Each approach has advantages and disadvantages. Individual school systems must decide what is best for them given their unique circumstances. Whether using in-house or contracted services, pest management personnel should be trained to:

- Understand the principles of IPM.
- Identify pests and associated problems or damage.
- Monitor infestation levels and keep records.
- Know cultural or alternative methods.
- Know recommended methods of judicious, least-hazardous pesticide application.
- Know the hazards of pesticides and the safety precautions to be taken.

- Know the pesticide label's precautionary statement(s) pertaining to exposure to humans or animals.

2.7.2 In-House Services

One of the most important tasks for an in-house program is training staff to function within an IPM framework. Universities and State Cooperative Extension Services have the expertise to meet most IPM training needs. The Department of Pesticide Regulation has a School IPM training program to help train school districts. This guidebook is the basis of this training program. A Web site is also available with information and links for School IPM. See www.schoolipm.info.

2.7.3 Contracted Services

Pest control firms should work with the pest manager and the responsible school official to solve pest control problems. Use of an outside pest control firm may increase costs but eliminate the need to hire and train personnel and store pesticides. The contract should specify the use of least-hazardous IPM principles and practices in meeting pest management objectives.

When choosing a pest control firm, request references that attest to their knowledge and experience with least-hazardous IPM, as well as previous experience in schools. Contact the local Better Business Bureaus or state regulatory agencies (DPR at 916-324-4100 for landscape uses and the Structural Pest Control Board at 916-561-8700 for indoor uses) for information about whether they have received complaints about a pest control company. These state regulatory agencies can also provide information on pesticide applicator certification.

The pest management services contract should include IPM specifications. Contracts should be written to provide expected results. Pest management objectives specific to the site should be jointly developed, agreed upon, and written into the contract. Any special health concerns (such as those for old or young persons, for pets, or for individuals who are allergic) should be noted and reflected in the pesticides that can be used, or excluded from use.

If the school district is considering or has decided to use a contractor to implement an IPM program, the sample contracts in **Appendix I** can be used or adapted.

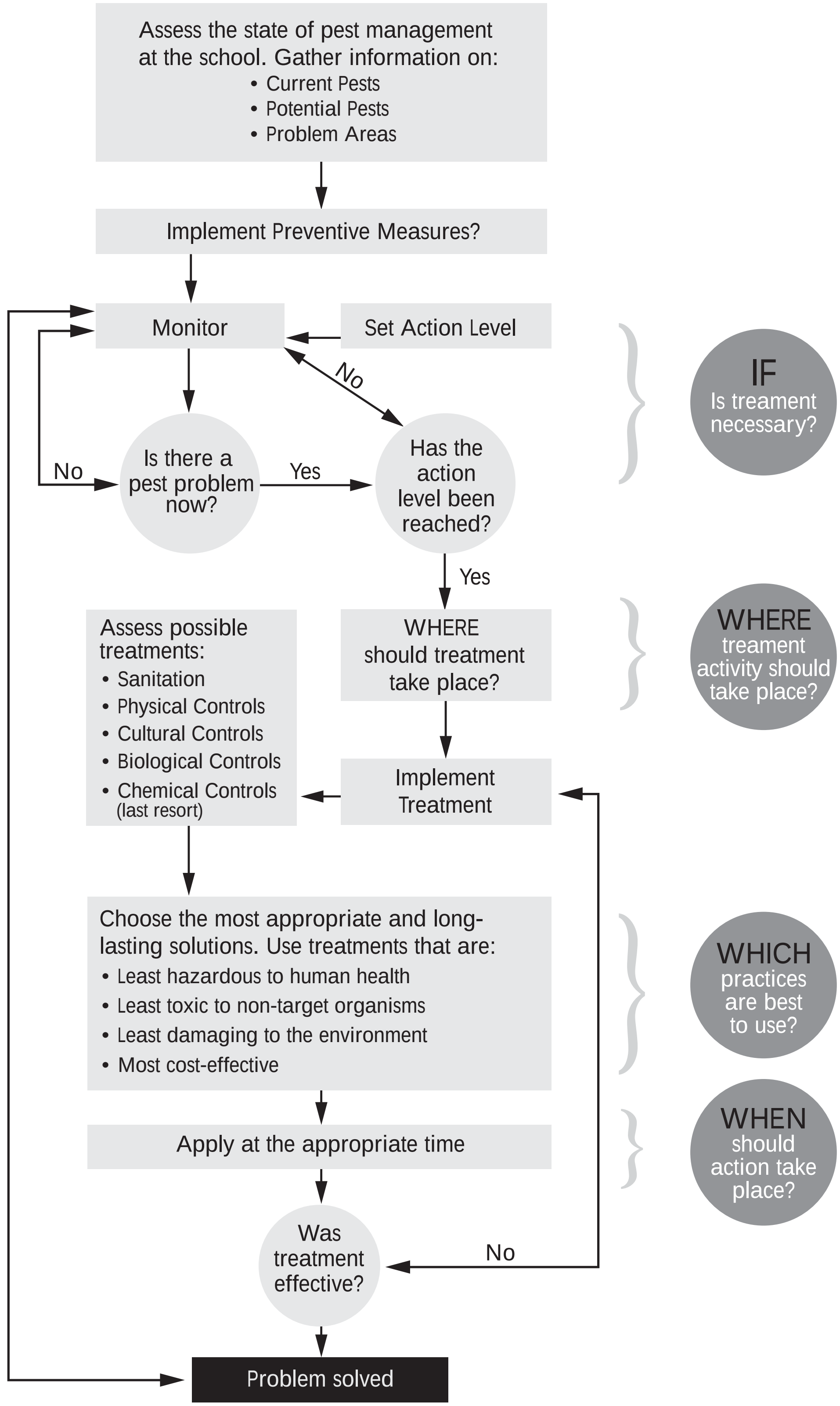
2.8 The IPM Decision-Making Process

This decision-making process, basic to IPM, helps answer four key pest management questions: IF treatment action is necessary, WHERE treatment activity should take place, WHEN action should take place, and WHICH mix of treatment practices are the best to use. See **Figure 2-1** for a flowchart of the IPM decision-making process.

2.8.1 IF Treatment Action Is Necessary

Instead of taking action at the first sign of a potential pest, the IPM process begins with asking whether any actions at all are needed (see section 4 for a discussion of injury and action levels). Sometimes, even a fairly large population of pests can be tolerated without causing a problem. In other cases, the presence of a single pest organism is considered intolerable. In still other cases, what is considered a pest by one group in society may be considered innocuous by another.

Figure 2-1: Flowchart of the IPM Decision-Making Process



Example: Occasionally when the weather is hot and dry, field cockroaches (Blattella vaga)*, small brown roaches that resemble the German cockroach, visit schools. Field cockroaches actually prefer to live outdoors in leaf litter and are only occasional indoor guests. By monitoring them with sticky traps, you'll see that their population is not increasing and they do not become established indoors.*

Example: Large rodent droppings and grease trails suggest there is a rat in a crawl space under the eaves. Even one rat can be a problem because it can gnaw on electric wires causing fires and leave fleas that can transmit pathogens to humans. Treatment action is usually required even if only one rat is suspected.

2.8.2 WHERE Treatment Activity Should Take Place

If it is decided that some treatment action is necessary, the IPM process encourages pest managers to look at the whole system for the best place to solve the problem. Treatment should take place where actions will have the greatest effect.

Example: When Argentine ants invade classrooms, it's tempting to douse them with an aerosol spray. Only a fraction of the worker ants are actually out foraging at any one time, and if these foragers are instantly killed, the pesticide doesn't poison nest mates and queens. It is more effective to eliminate indoor ant trails with soapy water and place self-contained baits outdoors. Ants will aggregate around the baits, so if you locate these indoors, you'll attract even more ants from outlying areas in the place where you don't want them.

2.8.3 WHEN Action Should Take Place

The timing of treatments is important. Often there is an optimal time in the life cycle of the plant or the pest to apply control measures. Conversely, there may be times when treatments actually increase pest problems. The human social system will also affect the timing of treatments. The IPM process encourages managers to discover the best timing for treatment actions (see section 5.2, "Timing Treatments") since long-term success of any treatment depends on timing.

Example of timing in the life cycle of a plant: Yellow starthistle, Centaurea solstitialis*, is an annual weed that grows in disturbed areas. As with many weed species, mowing before the plants flower is much more effective than battling seed head-laden plants later in the season.*

Example of timing in the life cycle of a pest insect: In the spring, yellow jacket queens are busy establishing nests. It's much more effective to trap these queens and the first flush of foraging workers then, rather than waiting until summer or fall when putting out traps will barely make a dent in the population.

Example of timing in the social system: When switching to IPM, it is essential to coordinate the IPM program plan with the overall budget process of the school district. For example, improving rodent and fly management may require modifications in food storage facilities or in the disposal of kitchen garbage. Substantial repair to windows or plumbing may be needed. Requesting funds for activities such as minor construction or new containers must be done at the appropriate time in the school district's budget development process.

2.8.4 WHICH Mix of Treatment Practices Are the Best to Use

There are three guiding principles to use when choosing treatments: conserve and enhance naturally occurring biological controls; use a multi-tactic approach; and view each pest problem in its larger context.

Conserve and Enhance Naturally Occurring Biological Controls

In a landscape setting, when we kill the natural enemies of pests, we inherit their work. In many cases, the combined action of all natural enemies present may result in substantial pest control. Even when they are not able to do the complete job, natural enemies are nonetheless providing some help in protecting school landscape plants from pest insects. The IPM program should be designed, when possible, to avoid damaging natural enemies.

(See "Biological Controls" in section 5.3 for more information).

Example: Many spider mite populations on various trees and shrubs are kept under control by naturally occurring predatory mites. In fact, the predators keep them under such good control we may never be aware of their presence until we spray a pesticide intended to kill more obvious pests, such as aphids. For a number of reasons, most pesticides are more harmful to the predatory mites then the pest mites. The pesticide kills almost all of the predators, the spider mites are only slightly affected, and now that they are free from their natural enemies, the pest mites quickly multiply and devastate the plant. By changing the practices for controlling the aphids, a spider mite problem can be avoided.

Use a Multi-Tactic Approach

Every source of pest mortality, no matter how small, is a valuable addition to the program. Biological systems are so complex, rarely will a single practice, such as the application of a pesticide, solve the problem for long. As many non-hazardous practices as needed should be combined to manage the pest problem.

Example: Controlling cockroaches requires direct practices such as applying boric acid dust to cracks, crevices, and wall voids; placing baits in areas inaccessible to students; using an insect-growth regulator and boric acid water washes in areas not in direct contact with food or people; and releasing parasitoids for certain roach species. But long-term cockroach control must also include habitat modification such as caulking or painting closed cracks and crevices; screening vents that may be used by cockroaches to travel between adjacent areas; eliminating water leaks and cracks around plumbing fixtures; and improving the storage of food supplies and organic wastes.

View Each Pest Problem in Its Larger Context

Each pest problem must be considered within the framework of the larger system in which it has arisen. Textbooks and manuals commonly treat pest problems one by one. However, in the real world setting of a school and the grounds around it, pest problems occur several at a time or in a sequence in which the management of one influences the others. In addition, pest problems are influenced by other human activities such as waste disposal and food handling indoors, and mowing, fertilizing, and irrigating outdoors, as well as the attitudes of the many people who work and study within the district. Using IPM means taking a whole system or ecosystem management approach to solving a pest problem.

A successful IPM program considers all of the components of an ecosystem. As biologists and ecologists use the term, an ecosystem is usually thought of as containing non-living (abiotic) and living (biotic) components. For instance, if one considers a school building as an ecosystem, the abiotic components of the building would be the building itself and the equipment and furnishings within it. The biotic components would be the people, insects, spiders, and other creatures that live or work in the building.

It is essential to consider who is involved in an IPM program—the social/political components. In a school system, this category includes teachers, students, custodians, grounds maintenance staff, food handlers, clerical staff, health personnel, carpenters, plumbers, pest control companies, refuse collectors, and other outside service providers who might be contracted for specific work in or around the school. The school district administration and school board, school neighbors or adjacent landowners, associated public agencies or institutions, professional associations and community groups, and the public must be included. The political and legal constraints of society should also be taken into consideration.

The many components of the school ecosystem can be thought of as a series of systems, each having an impact on the other and all potentially impacted by a pest management program. To design and implement a successful IPM program, it is necessary, at least to some degree, to be aware of and obtain information from each of these components.

This raises the classic problem in systems management: where to draw the boundary of the system. If the boundaries are drawn too narrowly and include only the pest, something important may be missed, like the fact that people are leaving food out at night that feeds the pest. It is better to read, question, and observe as much as possible about the larger system in which the pest problem exists. Otherwise, there is a risk that the solution to the pest problem will be overlooked.

Example: A nuisance fly problem inside the school may prompt use of space sprays or pesticide-impregnated plastic strips. A less hazardous quick fix might be to purchase and install electric insect traps. A broader view could lead to the observation that some window screens need repair and could be improved by the addition of weather-stripping around the frames to exclude flies. A still-larger view might include the observation that the outdoor trash containers on the school grounds are inappropriately placed or not adequately cleaned after being emptied each week, thus attracting flies.

Changing these conditions will involve cooperation from the custodial and maintenance staff. Perhaps the outdoor trash receptacle needs to be moved a greater distance from the door. Perhaps more frequent removal and replacement of the outdoor trash receptacle may be desirable. This will undoubtedly have budgetary consequences and will involve negotiations outside immediate school personnel. Ultimately it may be discovered that the flies are part of a community-wide problem. Complaints from the school system to the local municipal government may help in changing area-wide waste management practices. At first it may seem that there is little that a few individuals can do to influence the process of change in the larger ecosystem; however, the individual schools and the school district can assume a leadership role in educating their community about safer and more lasting methods of pest management. This can be done indirectly by educating the student population, and directly through the participation of school personnel in community forums on pest management-related matters.

Please see section 5, "Selecting Least-Hazardous Pest Control Practices" for more detailed information on the IPM decision-making process.

2.9 IPM Program Evaluation

An IPM-oriented program views the need to regularly apply pesticides as an indication that the program isn't working efficiently, and seeks other solutions in order to reduce pesticide use. One of the most important components of an IPM program is evaluating whether the IPM policy is being implemented and that specific pest problems are being solved. Evaluation is rarely done in conventional pest control. Evaluation should occur after each treatment and may involve monitoring.

For purposes of overall evaluation, it is helpful to view the IPM program as composed of many simultaneously occurring, interacting systems or processes. These can be either technical or administrative in nature.

Technical aspects to consider include:

- Prevention of pest infestations.
- Pest monitoring.
- Recordkeeping.
- Decision-making regarding pest treatment activities.
- Delivery of pest treatments.
- Evaluation of treatments.

Administrative aspects to consider include:

- Collection and cataloging of reference materials on management of the pests.
- Education and training of school personnel in IPM.
- Communication to school personnel regarding IPM program plans and progress.
- Budgetary planning.

Each of these components should have, as part of the development of the initial program plan, some expressed objectives or criteria by which the component is judged successful or not. Nevertheless, in addition, it is important to determine the following:

Were all the necessary components to the program actually developed?

Were they integrated successfully?

Were the right people involved in the integration of the components into a whole program?

2.9.1 Questions to Ask After Treatment Action

At the end of the year, use monitoring data to answer the questions below and make any necessary adjustments in methods for the next season. After two or three seasons of fine-tuning, including modifying the habitat, redesigning parts of the school facility, or changing behavioral practices to discourage pests, it is reasonable to expect problems to have lessened considerably, and in some cases disappear. After reaching this point, periodic monitoring rather than active management may be all that is needed. See also **Appendix L**, *Pest Management Assessment Tool.*

Was the pest population adequately suppressed below the set injury level?

Was the pest population suppressed in a timely manner?

Was the planned procedure used? If not, what was different?

What damage was produced? What damage was tolerable?

In the landscape, were natural enemies affected by treatments? How?

If natural enemies were killed by a pest management treatment, will this cause a problem elsewhere or at a later period?

Were there any other side effects from the IPM treatments? Were there any unanticipated consequences (good or bad)?

If ineffective, should the treatments be repeated or should another kind of treatment be evaluated?

Is the plant or structure worth maintaining? Can the site be changed to eliminate or reduce the problem for the same costs of treatment?

What were the total costs of the treatment—costs of suppression vs. cost of damage, costs of unexpected consequences, costs of risks from pesticides or benefits from reduction of pesticide.

2.9.2 Assessing Cost-Effectiveness

Cost-effectiveness is crucial to continuation of an IPM program. According to U.S. EPA (U.S. EPA, 1993), "preliminary indications from IPM programs in school systems suggest that long-term costs of IPM may be less than a conventional pest control program." Data from IPM programs in school systems and park districts across the country show that IPM can cost no more than conventional spray programs, and often costs considerably less. A DPR survey conducted in 2002 received responses from more than 400 school districts in California (Geiger and Tootelian, 2002). Some examples of cost-effectiveness are discussed below.

Two schools in Santa Barbara County, Peabody Charter School and Vista de Las Cruces, were demonstration sites in the Pesticides Reduction in Schools Project. The project was funded by U.S. EPA and the Santa Barbara Foundation, and managed by the Community Environmental Council and Organic Consulting Services (Boise and Feeney, 1998). They found that an IPM-based system was more effective in controlling pests, while saving money.

Staff time devoted to controlling ants at Peabody Charter School was reduced from eight hours per week to two and a half hours per week, a reduction of 70 percent. Long-term control of cockroaches required an initial investment of 14 hours to caulk cracks and crevices and to apply boric acid. These treatments for cockroaches did not have to be repeated and pest populations decreased. The cost of these treatments was $705.

Vista de Las Cruces School contracted for their pest control services prior to the IPM program. The monthly perimeter sprays to control indoor pests cost $1,740 per year. The school chose to cancel the contract and assign all pest management duties to the head custodian. The expenditures for pest management were reduced to $270 for a two-year period and the head custodian did not spend any additional time on pest management. Weeds are another pest management challenge at Vista de Las Cruces School. An application of mulch is expected to control weeds for three to five years and to cost $2,170. The previous cost of chemical herbicides was $934 per year, not including labor.

The Ventura Unified School District has reduced its reliance on herbicides by 95 percent while staying within historical spending limits for weed control materials. The money saved on herbicides was used to purchase mulch and a steam weeder with money left over for a contingency fund.

The Ann Arbor School District in Michigan found that hiring a contractor to monitor 35 schools on a regular basis, and treat only if action levels were reached, resulted in only a single treatment (a crack-and-crevice application of boric acid for cockroaches) during the course of a full year. In the first IPM year, this program cost the same as the previous conventional program. Costs were expected to drop the second year when in-house staff were scheduled to assume monitoring responsibilities (Cooper, 1990). In the 1999-2000 school year, 9 percent of the total budget for the Ann Arbor School District was used for operations and maintenance (Ann Arbor Public School District Web site at http://aapswww.aaps.k12.mi.us/).

A conventional pest control program at the Monroe County School District in Indiana, a 19-school district cost $34,000 annually. After an IPM program was implemented, the cost dropped to $28,000 (Forbes, 1991). As of 1998, the district realized a 35 percent reduction in pest management costs ("Cost of IPM in Schools" at http://spcpweb.org/schcost.pdf).

Whether an IPM program raises or lowers costs depends in part on the nature of the current housekeeping, maintenance, and pest management operations. The costs of implementing an IPM program can also depend on whether the pest management services are contracted out, performed in-house, or both.

Before 1985, Maryland's Montgomery County Public Schools had a conventional pesticide-based program. More than 5,000 applications of pesticides were made to school district facilities that year. Public concerns about potential hazards to students and school personnel led to development of an IPM program that emphasized prevention through sanitation and habitat modification, and less hazardous baits and dusts in place of conventional sprays. By 1988, annual pesticide applications had dropped to 600, and long-term control of pests had improved. According to William Forbes, pest management supervisor for the district, under conventional pest control in 1985, the district spent $513 per building per year. This covered two salaries, two vehicles, and materials for two employees who serviced 150 sites. Only crawling insects and rodents were managed by in-house staff. The IPM program serviced 200 school buildings (a 33 percent increase in the number of sites) for a cost of $575 per building per year, which covered three salaries, three vehicles and supplies. Contracting services, however at 11 of the sites cost an additional $2,400 per building per year under the conventional program. By 1988, under an IPM program, those same eleven sites were being managed by in-house staff at a cost of only $500 per site per year. In addition, no outside contracting was needed and the program covered virtually every structural pest, from pigeons to termites (Forbes, 1991). In 2002, operations and maintenance costs were $1.7 million out of a total budget of $1.4 billion (Montgomery County Public School District Web site).

During the start-up phase, there are usually costs associated with conversion to IPM. This is particularly true in schools that have not been well-maintained. Examples of these one-time expenses that may produce future budgetary savings include:

- Installing physical barriers such as air curtains over the outside entrances to kitchens to reduce flying insect problems. This is a one-time cost and results in fewer flying insect problems and a savings in years to come.
- Stepping up structural maintenance to correct such situations as leaky pipes. This effort reduces future maintenance problems, prevents pest problems, and saves money and energy in the long term.
- Training and/or certifying staff in IPM. The amount of information necessary to implement IPM is greater than that required for conventional pest control. As a consequence, training or certifying staff in IPM will probably increase costs.
- Re-landscaping the area adjacent to buildings to discourage pests.

Other expenses might include staff training, building repair and maintenance, new waste storage containers, screening, traps and/or a turf aerator. These expenses are usually recouped within the first few years of the program, and benefits continue to accrue for years.

Whether such costs are budgeted as a pest control expense or distributed to the building maintenance budget or the landscaping account depends on the budgetary format of the school system. In the long term, training, repair and maintenance activities, and equipment purchases will reduce overall costs of the pest control operations, as well as other maintenance and operating budgets.

2.9.3 Efficient Procurement

Some non-pesticide products, such as traps, can be stocked to reduce purchases in future years, but few savings can be realized by purchasing pesticides in bulk. It is probably best to keep no more than a 60-day pesticide inventory to assure product freshness and to avoid limiting cash flow. Pest managers should be able to anticipate needs to fit a 60-day buying schedule.

Successful practice of IPM relies on accurate recordkeeping, which leads to procurement that is more efficient. As the IPM program progresses, predictable events and pest control needs will be identified. Close consultation with the pest management specialist is essential for good decisions on purchases within the budget.

SECTION 3

Monitoring Pest Populations and Damage

IPM is based on consistently inspecting and monitoring for pests. The purpose of monitoring is to supply recent, accurate information with which appropriate decisions for managing pests can be made. Guidelines for making appropriate decisions can be established prior to monitoring (see section 4 on "Setting Injury and Action Levels"). Since each site is different, pest management decisions will depend on the circumstances encountered.

Monitoring as part of IPM was originally developed for agriculture. Over the years, this concept has been adapted for gathering information on pests of landscapes and structures in urban settings.

A regular and ongoing monitoring program will help answer the following questions:

- What is the extent of existing pest problems?
- Where are they located?
- What other pest problems exist?
- How are pests entering the building?
- What are the pests' sources of food, water, and shelter?
- Are there conditions conducive to future pest problems that can be corrected?

This section provides a general overview of how to set up and operate a monitoring program. Detailed discussions on monitoring techniques for individual pests are provided in Part 2.

3.1 What Is Monitoring?

Monitoring is the planned, regular visual inspection of an ornamental planting, landscape or structure for detecting pests, pest damage or conditions conducive to pests or pest damage. Monitoring should take place in areas where pest problems do or might occur. Monitoring frequently includes the use of pest traps, such as sticky traps for cockroaches. Information gathered from these inspections is always written down to help determine what actions to take. Examples of monitoring forms are provided in **Appendix M**. An inspection checklist for detecting structural decay and structural pest damage is provided in **Appendix N**.

3.1.1 Not Enough Time or Money?

Time and money will constrain what will realistically be possible. The most important thing is to go out and look at the problems, and write down what is observed. Figure out how monitoring can be included along with routine maintenance activities to ensure that this will be done. Make sure that personnel who are asked to monitor understand what to look for and how to record the information. Supply them with easy-to-use monitoring forms whenever they go out. If the school is contracting out its pest control services, give the pest control company copies of these forms to use or have them develop their own forms subject to the approval of the school's pest manager.

3.1.2 Levels of Effort Used in Monitoring

Monitoring need not be time consuming. The idea is to match the level of monitoring effort to the importance of the problem. Monitoring can vary from the extremely casual to the statistically strict, depending on what is most appropriate. The levels of effort are:

1. Reports from other people's (e.g., teachers) informal observations. This can be useful if used with a pest-sighting log to record verbal reports.
2. Monitoring as part of other tasks, with written observations. This serves to catch pest problems as they begin.
3. Careful inspection with written observations should be conducted when pest problems are significant.
4. Regular written observations and quantitative descriptions are appropriate when working on a pest problem related to public health.

3.2 Why Monitor?

A monitoring program increases familiarity with the workings of the target system. This knowledge allows anticipation of conditions that can trigger pest problems, and thus prevent them from occurring or catch them before they become serious. Monitoring enables intelligent decisions to be made about pest management actions, such as sealing cracks or setting traps.

Monitoring helps determine if action is needed. Is the pest population getting larger or smaller? If plants are being monitored, is the natural enemy population getting larger or smaller? These questions affect whether or not treatment is needed. These answers depend on inspection of the problem sites on several different occasions. How many pests or how much pest damage can be tolerated? This is also referred to as setting injury and action levels, which is discussed in detail in section 4. Even when tolerance for pest presence is at or near zero, as in the case of rats, monitoring will result in early pest detection, reducing the likelihood of unexpected pest outbreaks.

Monitoring helps determine where, when, and what kind of treatments are needed. This includes preventive treatments such as pest proofing and sanitation. Monitoring will show where these are most needed. It is unnecessary (and expensive) to treat all parts of a building or all plants on the school grounds for a pest when not all areas may be equally infested. Monitoring will pinpoint infestations and problem areas. On plants, monitoring will help time treatments to target the most vulnerable stage of the pest. The vulnerable stage may vary depending on the type of treatment used.

Monitoring allows evaluation of pest management actions. Monitoring after an action will show the success or failure of that action, so that future actions can be modified.

- Did the action reduce the number of pests below the level that causes intolerable damage?
- How long did the effect last?
- Did the action have to be repeated?
- Were there undesirable side effects?
- Do pest management action plans need to be adjusted?

3.3 What to Monitor?

Monitoring plants and their pests includes the regular observation and recording of:

- The condition of the plants (their vigor and appearance).
- The kind and abundance of pests (e.g., insects, mites, moles, weeds) as well as natural enemies (such as ladybugs, spiders, lacewing larvae and syrphid fly larvae).
- The amount of plant damage.
- Weather conditions (record any unusually dry, hot, wet, or cold weather in the last few weeks).
- Human behaviors that affect the plants or pests (e.g., foot traffic that compacts the soil, physical damage to plants caused by people, insistence on having certain plants grow in inappropriate situations).
- Cultural practices (e.g., pruning, fertilizing, mulching, treating pests) and their effects on the plants and the pest population.

Tables 3-1 and **3-2** provide more information to help quantify monitoring information. Using the abundance ratings in **Table 3-2** will make monitoring faster and easier, and will help standardize observations. If data that is more precise is needed, count the number of pests or their signs in a given area or on a certain number of leaves.

Monitoring weeds should be a seasonal activity timed to determine new weed pests or those that escaped treatment.

- Evaluate cultural practices that may favor weeds such as mowing, aeration, fertilizer use and irrigation practices.
- Review foot traffic patterns that may increase weeds.
- Monitor in spring and summer when most weeds are present and can be identified.

Monitoring structures involves the regular observation and recording of:

- The conditions of the building inside and out (structural deterioration, holes that allow pests to enter, conditions that provide pest harborage).
- The level of sanitation inside and out (waste disposal procedures, level of cleanliness inside and out, conditions that supply food to pests).
- The amount of pest damage and the number and location of pest signs (such as rodent droppings, termite shelter tubes and cockroaches caught in traps).
- Human behaviors that affect the pests (working conditions that make it impossible to close doors or screens, food preparation procedures that provide food for pests, etc.).
- Management activities (e.g., caulking, cleaning, setting out traps, treating pests) and their effects on the pest population.

Table 3-3 provides specific information on monitoring tools for both plants and structures.

3.4 Identifying the Target Pest

It is extremely important to correctly identify the problem pest and the cause of the pest problem. A pest cannot be effectively managed without knowing what it is or why it is present. For instance, putting out mousetraps to control what is really a rat problem can only result in failure. Setting out ant baits without caulking their entry point will not prevent more ant problems later. The UC IPM Pest Notes in Part 2 provide information that will help identify some of the most common pests found in and around schools. Take a specimen to a professional for identification for unusual pests. **Appendix K** describes how to properly collect and preserve an insect or plant specimen when seeking identification.

Once the pest is identified, read about its life cycle, food sources, habitat preferences, and natural enemies. Part 2, the UC IPM Pest Notes, will provide this information for the common pests, but if the pest is not included here, check the

Recommended Reading section, **Appendix H**, at the end of this manual for books that can help. Knowing the life habits of the pest will give clues about what to look for when monitoring and help decide how to best manage the pest.

If only damage symptoms and not the pest itself are visible, a sleuthing job is in order. More observation or observation at a different time of day may be necessary. Talk to other pest management professionals, local gardeners, nursery personnel, Cooperative Extension staff, or university researchers.

3.5 Timing Monitoring Activities

Timing and frequency of monitoring differs depending on the site and the pest(s). Outdoors, monitoring usually begins when plants put out new leaves in spring, and ends when leaves fall in autumn. Plants with annually recurring pest problems receive more attention than relatively pest-free plants. Monitoring can be incorporated into routine grounds maintenance activities such as weekly mowing, or can be a separate activity that occurs bi-weekly, monthly, or less frequently, depending on plant, pest, site, weather and other factors.

Indoors, monitoring might occur weekly during the early stages of solving a serious pest infestation, then taper off to monthly, once the pest problem is under control. Some pests are more active at night than during the day, thus, some monitoring may need to occur after dark. This is usually only necessary when trying to identify a nocturnal pest or trying to determine its travel routes and feeding habits. Once this is known, nighttime monitoring can often be replaced by daytime inspection of traps and plant foliage for signs of pest presence.

3.6 Recordkeeping

A monitoring program is only as useful as its recordkeeping system. Records serve as the memory of the IPM program. Written records should be kept since they are more accurate and detailed than human memory. Use of written records can avoid erroneous conclusions when comparing effects of treatment or other variables on the pest problem.

Recordkeeping is important to the pest manager because:

- Written observations about the specific pests and their management increase the pest manager's knowledge.
- More can be learned about the specific pest problems because details, such as past treatment success or failure won't be forgotten.

Recordkeeping is important to the school system and the IPM program because:

- Monitoring records form the basis for making decisions on the most sensible distribution of available resources to the areas most in need of attention or observation.

- Information can be easily and accurately passed from one employee to another.
- Information is not lost when employees leave or retire.

What Should the Records Show?

The record should always show:

- **What** is being monitored—name of the pest (common name and scientific name, if possible), stage of the pest (immature, adult), and for landscape pests, the name of the plant.
- **Where** monitoring is done—a map is always useful.
- **When** monitoring occurs—date and time.
- **Who** is doing the monitoring?

The rest of the information to record is listed under "What to Monitor," above. As mentioned before, the information in **Tables 3-1** and **3-2** will help to standardize some of the observations. Table 3-1 is specifically for plants, but **Table 3-2** can be used for structural pests as well as plant pests.

It is also important to standardize the format and the process by which the records are kept in order to maintain continuity from season to season and person to person. See

Appendix M for sample forms. Design forms with boxes to be checked off so less writing will be necessary.

Pest patterns emerge quickly when data gathered during monitoring are made visual, facilitating decision-making. This can be done by hand on graph paper, or by using one of the many graph-making features included in spreadsheet software. **Figure 3-1** shows fluctuations in cockroach trap counts.

No Time for Recordkeeping?

Try to make recordkeeping as easy and practical as possible. A person who is on the site frequently should be the person who monitors and keeps records. Try other solutions such as:

- Asking an interested parent to help record monitoring information, either by following the pest manager or by interviewing the person later.
- Setting up a small student project to follow pest managers around and record what they do.
- Having a quarterly or monthly meeting to discuss monitoring and using a cassette recorder to record the information.

3.7 Evaluating the Actions

Without evaluating the actions taken to reduce the pest problem, it will not be possible to improve the management program from year to year. Ask the following questions:

- Was the pest problem a significant one?
- Were the actions taken necessary or would the problem have gotten better if left alone?
- Did the actions taken and the least-hazardous treatments used adequately solve the problem?
- Could the problem be managed better next time? If so, how?
- Is more or better information needed to make treatment decisions in the future?

See **Appendix L** for sample pest management assessment of a school IPM program.

Table 3-1: Plant Condition Rating*

	Indicators of Plant Condition			
Plant Condition Rating	*Leaf Color*	*Amount/Size of Growth*	*Damaged Plant Parts*	*Presence of Pest Problems*
EXCELLENT	Good	Adequate	None to few	No major ones
GOOD	Good	Slightly reduced	Few to common	A few minor ones
FAIR	Poor	Much reduced	Common to abundant	Either major or minor ones occurring frequently
POOR	Poor	Severely reduced	Innumerable	Both major and minor ones occurring frequently

Leaf Color: Note that there are healthy plants that do not have bright green leaves. Leaves can be purple, yellow, or sometimes a mottled yellow and green (variegated). “Good” leaf color will not always be the same; it will depend on the kind of plant.

Amount/Size of Growth: This refers to the length of the new growth for the season as well as the number of new leaves, and the size of the leaves, flowers, or fruit.

Damaged Plant Parts: Look at the whole plant. Are there leaves with holes, spots, or discolorations? Are there wilted or dead leaves? Are there dead twigs or branches? Is the damage only on old leaves while new leaves look perfectly healthy?

Presence of Pest Problems: A major pest problem is one that has seriously affected or injured the plant and requires management. A minor pest problem may or may not have affected or injured the plant and may or may not require management.

*Adapted from Michigan State University, 1980

Table 3-2: Pest and Plant Damage Abundance Rating*

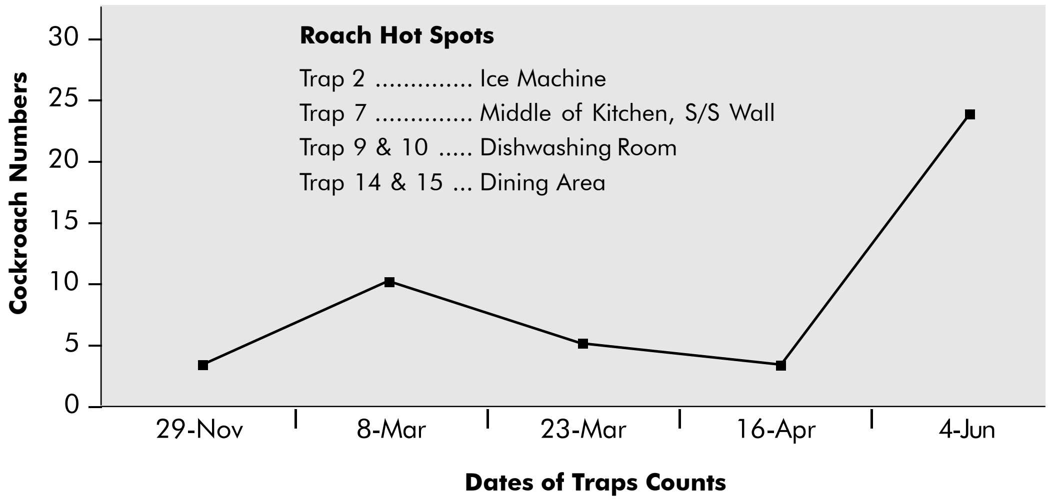
Abundance Rating	***Indicators of Abundance***
Few	Organisms or plant damage occasionally found, but only after much searching
Common	Organisms or plant damage easily found during typical searching
Abundant	Organisms or plant damage found in large numbers—obvious without searching
Innumerable	Organisms or plant damage extremely numerous—obvious without searching

*Adapted from Michigan State University, 1980

Table 3-3: Tools Used in Monitoring

Tools	***Use***	***Plants***	***Structures***
Monitoring forms	to write down what is seen	X	X
Maps or site plans of the buildings or grounds	to mark where pests are found and where traps are placed	X	X
Clipboard	to hold the monitoring forms and maps	X	X
Flashlight with a halogen bulb	to detect nighttime pest activity and for viewing darkened areas (e.g. under counters, in closets) during the day. A black light bulb can be substituted to detect scorpions.	X	X
Sticky traps (for many insects the color of the trap is important, e.g., thrips are attracted to blue; whiteflies prefer yellow). Glue boards are used for monitoring rodents.	to monitor a variety of insects, mites, and small rodents.	X	X
Hand lens (a small magnifying glass)	to help to see mites and small insects A lens that magnifies things at least 10 times (=10X) is usually adequate. A 15X lens can be used to distinguish among various mite species and other similarly small pest organisms such as thrips.	X	X
Plastic bags or small vials	to hold specimens for later examination or identification.	X	X
Small knife or screwdriver	to dig up weeds for specimens or for control, to probe damaged wood and to extract insect droppings from wood.	X	X
Ladder	for examining hard-to-reach spaces	X	X
Camera	for documenting pest damage to plants or structures before and after IPM methods have been applied	X	X

Figure 3-1: Fluctuating Cockroach Trap Counts



SECTION 4

Setting Injury and Action Levels

Total eradication of pest organisms is virtually impossible to achieve. A more realistic goal is to determine the injury level—the number of pests or the amount of pest-related damage that can be tolerated without suffering an unacceptable medical, economic, or aesthetic loss. The action level—the number of pests necessary for treatment to occur to prevent the injury level being reached—depends largely on pest biology and environmental conditions supporting the pest.

4.1 Determine Injury Levels First

Before determining the action level, first determine the injury level. This is the level of damage or the level of the pest population that causes unacceptable injury. The injury level will be higher than the action level (see **Figure 4-1** for sample thresholds).

4.1.1 Three Types of Injury

There are three types of injury relevant to school IPM programs:

- *Aesthetic injury* applies mainly to plants. This refers to injury that affects the appearance without affecting the health of the plant. There are few indoor pests or pests of structures that cause only aesthetic damage.
- *Economic injury* refers to pest damage that causes monetary loss, e.g., clothes moths destroying band uniforms or a plant disease that causes the death of a tree.
- *Medical injury* relates to human health problems caused by pests such as rodents, flies, yellowjackets and poison oak.

4.1.2 Injury Levels Differ Depending On The Pest And Its Location

The number of pests or amount of pest damage that can be tolerated (another way to think of injury level) will depend on the kind of pest and its location. A column of ants marching through an unused outbuilding is an entirely different situation from an ant invasion in the cafeteria. Many thousands of aphids can usually be tolerated on a tree, but one louse or nit on a child's head cannot.

Some pests are perceived as more frightening or disgusting than other pests, which in turn influences the number people will tolerate. Most people prefer crickets to cockroaches and find pigeons more acceptable than rats. Education and information can sometimes modify a person's tolerance level of a particular pest.

State, county, or local public health codes will have an impact on injury and action levels for pests such as rats, mice, cockroaches, and flies in areas where food is stored or prepared. In a public health emergency such as an outbreak of rabies or bubonic plague, government agencies may legally mandate control of certain pests. Consult the County Health Department for more information.

Box 4-1: Is a Response to an Existing Pest Population Needed?

- To determine whether a response is needed, ask the following questions:
- Are there state or county health codes requiring control of the pest problem (i.e., pests in areas where food is stored, prepared, or served)?
- Is the pest population growing?
- Are the pests located in a sensitive area (i.e., kitchens, cafeteria, or sick rooms)?
- Are the pests posing a health threat to humans?
- Are the pests damaging school property?
- Are the pests annoying or worrying students, faculty, and staff?
- Are the pests causing unacceptable aesthetic damage?

4.1.3 Don't Set the Level Too Low

One of the major causes of unnecessary treatments for pests is an unrealistically low tolerance level. Obviously, there is little leeway in tolerance for pests that have consequences for human health or the school budget, but for many other pests, the range of tolerance can be very wide. By understanding what damage is serious and by simply changing the way we view pests and pest damage, we can avoid many unnecessary treatments. For instance, most trees and shrubs can support substantial populations of caterpillars, aphids, psyllids, or leafhoppers without coming to any harm. Lawns can still be very attractive and functional even though the grass is not all of one kind and there are a number of weeds mixed in (as long as they don't pose a tripping hazard).

4.1.4 Determining the Injury Level

We all have intuitive, unspecified notions of injury level in various pest management situations, but these may not be accurate. In an IPM program, the aim is to try to make injury levels clear and precise. Monitoring is the only way to do this. It also takes knowledge and experience to understand the life cycles of pests, how fast their populations grow, and whether their damage will have serious consequences.

Example: Weeds in lawns are often only an aesthetic problem, but in other instances weaken ornamental plants. You may decide to set an aesthetic injury level in a lawn at 15 percent, or treat weeds in landscaped areas as soon as they begin to compete with ornamentals.

4.2 Determine Action Levels Based on Injury Levels

The action level is the level of pest damage or number of pests that triggers a pest management action to prevent pest numbers from reaching the injury level. The action is not necessarily a pesticide application. The action level will be lower than the injury level (see **Figure 4-1** for sample thresholds). Determining action levels involves making educated guesses about the likely impacts of numbers of pests present in a given place at a given time. In other words, an estimate of how high the pest population can grow before action is needed to prevent unacceptable injury. The action level must be determined and treatments applied before the injury level is reached.

Example: From previous experience, if more than ten cockroaches are found in a sticky trap in a classroom, teachers and students will complain. At two cockroaches per trap, no one notices that roaches are present. When there are *between two and ten roaches per trap, the treatment may consist of tracking down the infestation, sealing holes and cracks near the infestation, fixing leaks, and applying cockroach bait. At the same time, review food storage, sanitation, and trash handling procedures with the teacher. If catches exceed ten roaches per trap, check equipment and other inaccessible areas for harborage; vacuum and thoroughly clean the room; and ask the teacher to remove clutter and straighten all storage areas.*

4.2.1 Set Conservative Action Levels in the Beginning

During the beginning phase of an IPM program, it is wise to be conservative when establishing an initial action level. Set it low enough (i.e., low numbers of pests trigger treatments) to insure a wide margin of safety while learning monitoring methods. The initial action level should then be compared with other action levels for the same pest at different sites or locations. This is necessary to determine if the action level is set too high or too low, if treatments were necessary or not, and if they were properly timed.

The easiest way to collect comparative data is to set aside a portion of a school that remains untreated at the time another area is treated, or to monitor two schools where different action levels are applied to the same pest. By monitoring both sites, and comparing records, adjustment of the initial action level up or down can be evaluated.

Periodically, the action level should be reevaluated for each pest and for each site. Changes in weather conditions, plant cultivars grown, horticultural practices, level of IPM experience of employees and building renovations can affect the setting of injury levels. See **Table 4-1** for example action levels for common school pests.

4.2.2 Avoid "Revenge" Treatments

Sometimes action takes place after the injury level has been reached and the pest population has begun to decline naturally, such as with seasonal changes (**Figure 4-2**). These "revenge" treatments are generally useless at controlling pests, are damaging to the environment, and an unnecessary expenditure of time and resources.

4.3 Declaring an Emergency Under the Healthy Schools Act

In the Healthy Schools Act, "emergency conditions" are defined as "circumstances in which the school designee deems that the immediate use of a pesticide is necessary to protect the health and safety of pupils, staff, or other persons, or the schoolsite." (Education Code section 17608(c))

Before an emergency occurs, the IPM coordinator (pest manager) must establish a communication "tree" with the names and phone numbers of people to contact in a crisis. Each contact should have a set of clearly defined responsibilities. For instance, the IPM coordinator notifies the public information officer who then handles the concerns of parents and the public. The IPM coordinator also notifies school administrators who decide who to notify at higher levels. The IPM coordinator must communicate effectively with all those involved in the emergency and must choose information that is appropriate for each person with whom he or she communicates. For instance, the superintendent will not need to be informed of specific mixing instructions for the pesticide, and the pesticide applicator will not need to know the names of the students and staff involved.

It is important to thoroughly document the emergency condition. Ask the following questions:

- **Who** is the person who is warning about the emergency? Is the person credible? Does he or she have the necessary knowledge to make a determination of an emergency?
- **What** is the problem? Find out as much as possible about the problem and what is causing it. What kind of pest is involved? Is the problem one of health and/or safety?
- **Where** is the problem? Is the location such that it is an immediate threat to health and safety? Can the area be cordoned off to prevent further problems?
- **When** did the problem occur? Is it happening at this moment, or did it happen two weeks ago, and is just now being reported?
- **How** did the problem occur? What are the circumstances surrounding the incident?
- **Why** did the problem occur? What factors contributed to the creation of the problem?

Once an emergency is declared and the channels of communication are open, the next step to take is assessing the possible options for solving the problem and choosing the most effective one. Once the treatment has been chosen, the IPM coordinator should communicate this decision. When the emergency is over, it is important to assess the effectiveness of the chosen course of action (see section 5 for more information) and to make adjustments in the pest management system so that the problem doesn't recur. This evaluation and the changes that are made should be reported to those involved in the emergency.

IPM is not simply a matter of substituting

Table 4-1: Examples of Action Levels* for Schools

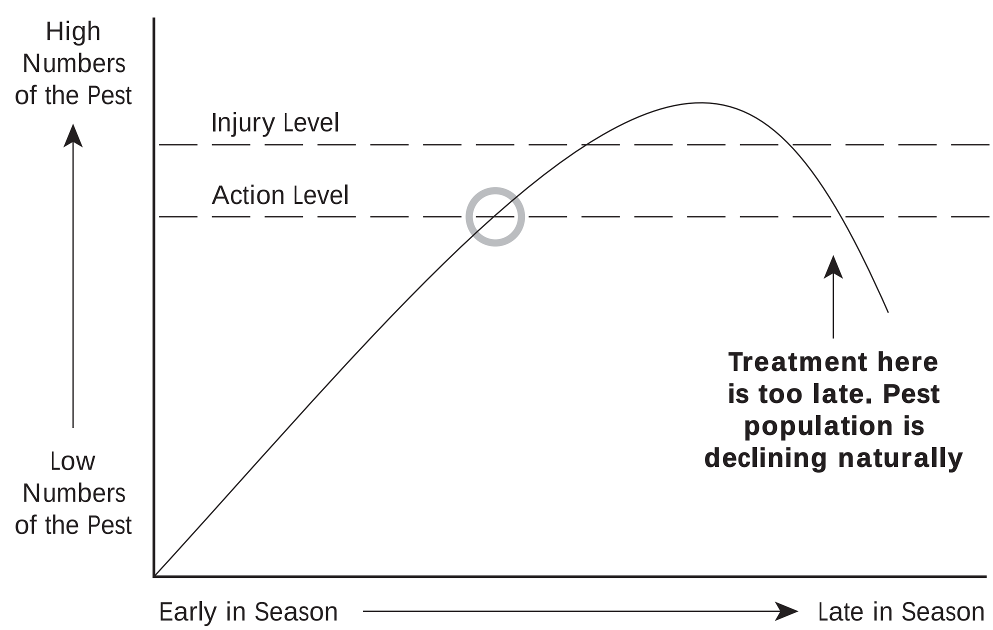
Pest	***Classrooms/ Public Areas***	***Maintenance Area***	***Infirmary***	***Kitchen***	***Grounds***
Ants, Argentine	5/room	5/100 ft^2 in 2 successive periods	1/room	3/room	1 nest within 25 ft of bldg.
Ants, carpenter	3/room	3/room	1/room	2/room	1 nest within 25 ft of bldg.
Bees, honey	1/room	3/room	1/room	1/room	If children threatened
Bees, bumble	1/room	3/room	1/room	1/room	If children threatened
Bees, carpenter	1/room	3/room	1/room	1/room	If children threatened; 1 carpenter bee/5 linear ft
Cockroaches	2/room	5/room	1/room	1/room	If noticeable or invading
Crickets	3/room	10/room	1/room	2/room	If nuisance
Grain & flour pests	1/package or container	N/A	N/A	1/package or container	N/A
Houseflies	3/room	5/room	1/room	1/room	5/trash can or 10 dumpster
Landscape Pest (general)	N/A	N/A	N/A	N/A	whenever damage approaches 10% per plant
Lawn pest (insects, nema-tode, disease)	N/A	N/A	N/A	N/A	whenever visible damage approaches 10% in any 100 ft^2 area
Lice (head or body)	Take no action, refer to nurse				
Mice	1/room	1/room	1/room	1/room	burrows or activity in any student area
Pigeons	Public area or roof: whenever droppings accumulate more than 1 inch or nests obstruct gutters or equipment. Roof ledges: 10/building for 3 consecutive inspections				
Poison Oak	Outdoor student activity areas: 1 plant Wooded areas: no control necessary unless near path or student activity area				
Rats	1/room	1/room	1/room	1/room	any burrow/activity
Silverfish	1/room	2/room	1/room	1/room	NA
Spiders, poisonous	1/room	1/room	1/room	1/room	1/activity area
Spiders, others	1/room	3/room	1/room	1/room	only if nuisance
Weeds	Lawns: whenever weeds approach 15% in any 100 ft^2 area Ornamental plantings: whenever competing with ornamental plans or whenever aesthetically displeasing				
Yellow jackets	Inside: 1/room; outside: 10/10 minutes at trash (this triggers more frequent trash pickup and/or search for nests)Outside in traps in early spring: 30 to 40 in 4 hours in a trap (this triggers area wide baiting)				

* The specific action levels mentioned in this table are offered as examples only. They are not required by regulation or law. Each school using action thresholds should develop action levels of their own, suited to specific conditions at the school.

This table was adapted from Pinto and Kraft, 2000.

Figure 4-1: Injury and Action Levels

Figure 4-2: Effect of “revenge” treatments.



Selecting Least-hazardous Pest Control Practices

SECTION 5

"good" pesticides for "bad" pesticides. Too often, we want an easy solution, a magic bullet that will solve all our problems in one shot. Unfortunately, pest management is complicated, and we cannot always expect a simple solution to pest problems. IPM works because combined strategies for pest management are more effective in the end than a single strategy. A good pest manager considers as many options as possible and tries to combine them into an effective program. The best pest managers have ideas for new and creative ways to solve pest problems. As defined by the Healthy Schools Act, IPM takes a preventive approach by identifying and removing, to the degree feasible, the basic causes of the problem rather than merely attacking the symptoms (the pests). This prevention-oriented approach is also best achieved by combining a number of treatment strategies.

5.1 Criteria for Selecting Least Hazardous Pest Control Practices

Once the IPM decision-making process is in place and monitoring indicates a pest treatment is needed, the choice of specific practices can be made. Choose practices that are:

- Least hazardous to human health.
- Least disruptive of natural controls in landscape situations.
- Least toxic to non-target organisms.
- Most likely to be permanent and prevent recurrence of the pest problem.
- Easiest to carry out safely and effectively.
- Most cost-effective in the short and long term.
- Appropriate to the weather, soils, water, and the energy resources of the site and the maintenance system.

5.1.1 Least Hazardous to Human Health

It is particularly important around children to take the health hazards of various strategies into consideration. Hazard refers to the extent and type of negative effects of the strategy in question.

Example: Aerosol sprays can kill cockroaches; however, they can also pose potential hazards to humans because the pesticide volatilizes in the air, increasing the likelihood of respiratory or lung exposure of students and staff. In addition, aerosol sprays may leave residues on surfaces handled by students and teachers. When cockroach baits are used instead, the pesticide is confined to a much smaller area, and if applied correctly, the bait will be out of reach of students and staff. Baits volatilize very little so lung exposure is not a problem. Cockroach baits manage cockroach populations much more effectively than aerosol sprays.

5.1.2 Least Disruptive of Natural Controls

In landscape settings, try to avoid killing off the natural enemies that aid in controlling pest organisms. Unfortunately, and for a number of reasons, natural enemies are often more easily killed by pesticides than are the pests. When choosing treatment strategies, always consider how the strategy might affect natural enemies. When choosing a pesticide, try to use one that has less effect on natural enemies. For help in determining this, see the resources listed in **Appendix G**.

5.1.3 Least Toxic to Non-Target Organisms

The more selective the control, the less harm there will be to non-target organisms in the environment.

Example: Aphid populations in trees often grow to high numbers because ants harvest the honeydew (sweet exudate) produced by the aphids, and protect them from their natural enemies. The ants that protect these aphid pests are often beneficial in other circumstances, aerating the soil and helping to decompose plant and animal debris. By excluding the ants from the tree with sticky bands around the trunk, it is often possible to achieve adequate suppression of the aphids without harming the ant populations.

5.1.4 Most Likely to Be Permanent and Prevent Recurrence of the Pest Problem

Finding treatments that meet this specification is at the heart of a successful IPM program because these controls work without extra human effort, costs, or continual inputs of other resources. These treatments often include changing the design of the landscape, the structure, or the system to avoid pest problems. The following are examples of preventive treatments:

- Educating students and staff about how their actions affect pest management.
- Caulking cracks and crevices to reduce cockroach (and other insect) harborage and entry points.
- Instituting sanitation measures to reduce the amount of food available to ants, cockroaches, flies, rats, mice, and other pests.
- Cleaning gutters and directing their flow away from the building to prevent moisture damage.
- Installing a sand barrier around the inside edge of a foundation to prevent termites from crawling up into the structure.
- Applying an insect growth regulator to prevent fleas from developing in an area with chronic problems.

5.1.5 Easiest to Carry out Safely and Effectively

While the application of pesticides may seem comparatively simple, in practice it may not be the easiest tactic to carry out safely or effectively. Use of conventional pesticides often involves wearing protective clothing, mask and goggles. In hot weather, people are often reluctant to wear protective gear because of the discomfort this extra clothing causes. By choosing not to wear the protective clothing, applicators not only violate the law but also risk exposure to hazardous materials.

5.1.6 Most Cost-Effective in the Long Term

In the short term, use of a pesticide often appears less expensive than a multi-tactic IPM approach; however, closer examination of the true costs of pesticide applications over the long term may alter this perception. In addition to labor and materials, these costs include licensing, maintaining approved pesticide storage facilities, disposing of unused pesticides, liability insurance, and environmental hazards.

Other factors to consider are whether a particular tactic carries a one-time cost, a yearly recurring cost, or a cost likely to recur a number of times during the season. When adopting any new technology (whether it be computers or IPM), there will be some start-up costs. IPM frequently costs less than, or about the same, as conventional chemically based programs, once the program is in place (see section 2.9.2 for a discussion on "Assessing Cost-Effectiveness").

In addition, parental and community concern about the use of conventional pesticides may make *any* use of pesticides in and around schools problematic. A public relations headache can develop over comparatively innocuous incidents, and require substantial amounts of time from the highest paid employees of the school district to attend meetings, prepare policy statements and other pest management duties. These costs should also be factored into the pest control equation.

5.1.7 Appropriate to the Weather, Soils, Water, and the Energy Resources of the Site and the Maintenance System

Skillfully designed landscapes can reduce pest problems as well as use of water and other resources. We cannot stress enough the importance of choosing the right plant for the right spot. Plants that are forced to grow in unsuitable sites where they are unable to thrive will be a continual source of problems. When plants die on the school site, take the time to find a replacement that is suited to the landscape. UCCE Master Gardeners are available in many counties for local planting recommendations. Look in the Yellow Pages under Government or go to http://ucanr.org/ to find the local County Cooperative Extension Office.

5.2 Timing Treatments

Treatments must be timed to coincide with a susceptible stage of the pest and, if possible, a resistant stage of any natural enemies that are present. Sometimes the social system (i.e., the people involved or affected) will impinge on the timing of treatments. Only monitoring can provide the critical information needed for timing treatments and thereby make them more effective.

Example: To control scales on plants using a low-hazard material such as insecticidal soap or horticultural oil, it is necessary to time treatments for the period (often brief) when immature scales (crawlers) are moving out from under the mother scales, seeking new places to settle down. It is at this stage that scales are susceptible to soaps and oils.

5.2.1 Spot Treatments

Treatments, whether pesticides or non-hazardous materials, should be applied only when and where needed. It is rarely necessary to treat an entire building or landscape area to solve a pest problem. By using monitoring to pinpoint where pest numbers are beginning to reach the action level and confining treatments to those areas, costs and exposure to hazardous materials can be kept to a minimum.

5.3 Summary of Available Treatment Options

The following is a list of general categories of treatment strategies. We have included some examples to help illustrate each strategy. The list is not intended to be exhaustive since products change, new ones are discovered or invented, and ingenious pest managers develop new solutions to old problems every day.

5.3.1 Education

Education is a cost-effective pest management strategy. Information that will help change people's behaviors—particularly how they store food and dispose of garbage—plays an invaluable part in managing pests like cockroaches, ants, flies, yellow jackets, and rodents. Education can also increase people's willingness to share their environment with other organisms so that people are less likely to insist on hazardous treatments for innocuous organisms. Teaching children about IPM will have a long-term effect on the direction of pest management as these students grow up to become consumers, educators, policy makers, and researchers. See **Appendix O** for training and licensing opportunities and **Appendix F** for IPM-related curricula and resources for the classroom.

5.3.2 Habitat Modification

Pests need food, water, and shelter to survive. If the pest manager can eliminate or reduce even one of these requirements, the environment will support fewer pests.

Design or Redesign of the Structure

Design changes can incorporate pest-resistant structural materials, fixtures and furnishings. Sometimes these changes can eliminate pest habitat. For example, buildings designed without exterior horizontal ledges will reduce pigeon problems. Inside, heavy-duty, stainless steel wire shelving mounted on rolling casters helps reduce roach habitat and facilitates cleanup of spilled food. For more information, a guide to pest management through prevention, "Pest Prevention: Maintenance Practices and Facility Design," can be located on the DPR School IPM Web site at www.schoolipm.info.

Sanitation

Sanitation can reduce or eliminate food for pests such as rodents, ants, cockroaches, flies, and yellowjackets.

Eliminating Sources of Water for Pests

This involves fixing leaks, keeping surfaces dry overnight, and eliminating standing water. Fixing any leaks has the added benefit of saving water.

Eliminating Pest Habitat

How this can be done will vary depending on the pest, but some examples are caulking cracks and crevices to eliminate cockroach and flea harborage, removing clutter that provides roach habitat, and removing dense vegetation near buildings to eliminate rodent harborage.

5.3.3 Modification of Horticultural Activities

Planting techniques, irrigation, fertilization, pruning, and mowing can all affect how well plants grow. A great many of the problems encountered in school landscapes are attributable to using the wrong plants or failing to give them proper care. Healthy plants are likely to have fewer insect, mite, and disease problems. It is very important that the person responsible for the school landscaping knows (or is willing to learn) about the care required by the particular plants at the school.

Designing/Redesigning of Landscape Plantings

- Choose the right plant for the right spot and choose plants that are resistant to or suffer little damage from local pests. This will take some research. Ask advice of landscape maintenance personnel, local nurseries, local pest management professionals, and County Extension agents or the master gardeners on their staffs.

- Include in the landscape flowering plants that attract and feed beneficial insects with their nectar and pollen, e.g., sweet alyssum (*Lobularia spp.*) and flowering buckwheat (*Eriogonum spp.*), species from the parsley family (Apiacae) such as yarrow and fennel, and the sunflower family (Asteraceae) such as sunflowers, asters, daisies, marigolds and zinnias.
- Diversify landscape plantings. A pest can devastate the entire area when large areas are planted with a single species of plant.

5.3.4 Physical Controls

Vacuuming

A heavy-duty vacuum with a special filter fine enough to screen out insect effluvia (one that filters out particles as small as 0.3 microns) is a worthwhile investment for a school. Some vacuums have special attachments for pest control. The vacuum can be used not only for cleaning, but also for directly controlling pests. A vacuum can pull cockroaches out of their hiding places and can capture adult fleas, their eggs, and pupae. A vacuum used outside can be used to collect spiders, box elder bugs, and cluster flies.

Trapping

Traps play an important role in least-hazardous pest control; however, in and around schools, traps may be disturbed or destroyed by students who discover them. To prevent this, place them in areas out of reach of the students in closets or locked cupboards. Another strategy is to involve students in the trapping procedures as an educational activity so they have a stake in guarding against trap misuse or vandalism.

Today a wide variety of traps is available to the pest manager. Some traps are used mainly for monitoring pest presence. These include cockroach traps and various pheromone (insect hormone) traps, although if the infestation is small, these traps can sometimes be used to control the pest. Other traps include the familiar snap traps for mice and rats, electric light traps for flies, and flypaper. There are also sticky traps for whiteflies and thrips, cone traps for yellowjackets, and box traps for skunks, raccoons, and opossums.

Barriers

Barriers can be used to exclude pests from buildings or other areas. Barriers can be as simple as a window screen to keep out flying and crawling insects or sticky barriers to exclude ants from trees. Barriers that are more complicated include electric fences to keep out deer and other vertebrate wildlife and L-shaped footings in foundations to exclude rodents.

Heat and Cold

Commercial heat treatments can be used to kill wood-destroying pests such as termites. A propane weed torch can be used to kill weeds coming up through cracks in pavement. Freezing can kill trapped insects such as yellow jackets before emptying traps, kill clothes moths, and kill the eggs and larvae of beetles and moths that destroy grain.

Removing Pests by Hand

In some situations removing pests by hand may be the safest and most economical strategy.

Tent caterpillars can be clipped out of trees, and scorpions can be picked up with kitchen tongs and killed in soapy water or in alcohol.

5.3.5 Biological Controls

Biological control uses a pest's natural enemies to attack and control the pest. We use the word "control" rather than "eliminate" because biological control usually implies that a few pests must remain to feed the natural enemies. The exception to this is a separate category of biological control called microbial control, which includes the use of plant and insect pathogens. Microbial controls are generally used like conventional chemical pesticides to kill as many pests as possible. Biological control strategies include conservation, augmentation, and importation.

Conservation

Conserving biological controls means protecting those already present in the school landscape. To conserve natural enemies you should do the following:

- Treat only if injury levels will be exceeded.
- Spot treat to reduce impact on non-target organisms.
- Time the treatments to be least disruptive in the life cycles of the natural enemies.
- Select the most species-specific, least-damaging pesticide materials, such as *Bacillus thuringiensis*, insect growth regulators that are specific to the pest insect, and baits formulated to be attractive primarily to the target pest.

Augmentation

This strategy artificially increases the numbers of biological controls in an area. This can be accomplished by planting flowering plants (also called insectary plants) to provide pollen and nectar for the many beneficial insects that feed on the pest insects or purchasing beneficials from a commercial insectary. Examples of the best-known commercially available natural enemies include lady beetles, lacewings, predatory mites, and insect-attacking nematodes. These are but a very small part of the large and growing number of species now commercially available for release against pests. Learning when to purchase and release them and how to maintain them in the field should be emphasized in any landscape pest management program. See the DPR Publication "Sources of Beneficial Organisms in North America" for commercial suppliers of biocontrol organisms (available online at http://www.cdpr.ca.gov/ under *Publications*).

Importation

People often ask if parasites or predators can be imported from another country to take care of a particularly disruptive pest in their area. It is true that the majority of pests we have in North America have come from other parts of the world, leaving behind the natural enemies that would normally keep them in check. "Classical" biological control involves searching for these natural enemies in the pest's native area and importing these natural enemies into the problem area. This is not a casual venture: it must be done by highly trained specialists in conjunction with certain quarantine laboratories approved by the United States Department of Agriculture. Permits must be obtained and strict protocols observed in these laboratories. Once the imported natural enemies become established in their new home, they usually provide permanent control of the pest. Patience is needed, however, because establishment of the natural enemies can take several years.

5.3.6 Microbial Controls

Microbial controls are naturally occurring bacteria, fungi, and viruses that attack insects and weeds. A growing number of these organisms are being sold commercially as microbial pesticides. Non-target organisms are much less likely to be affected because these microbial pesticides selectively attack pests.

The most well known microbial insecticide is *Bacillus thuringiensis*, or B.t. The most widely sold strain of B.t. kills caterpillars. Another strain kills only the larvae of black flies and mosquitoes, and a third strain kills only certain pest beetles.

Microbial herbicides made from pathogens that attack weeds are commercially available for use in agricultural crops. In the near future, there may be commercial products for use in urban horticultural settings.

5.3.7 Least-Hazardous Chemical Controls

The health of school occupants and long-term suppression of pests must be the primary objectives that guide pest control in school settings. To accomplish these objectives, an IPM program must always look for alternatives first and use pesticides only as a last resort. There are many chemical products to choose from that are relatively benign to the larger environment and at the same time effective against target pests. To find out whether a specific pesticidal product is exempt from the right-to-know requirements of the Healthy Schools Acts, see **Appendix B**.

"Least-hazardous" pesticides are those with all or most of the following characteristics: they are effective against the target pest, have a low acute and chronic toxicity to mammals, biodegrade rapidly, kill a narrow range of target pests, and have little or no impact on non-target organisms. There are many least-hazardous products being registered in California, including materials such as the following:

- Pheromones and other attractants.
- Insect growth regulators (IGRs).
- Repellents.
- Desiccating dusts.
- Pesticidal soaps and oils.
- Some botanical pesticides.

Pheromones

Animals emit substances called pheromones that act as chemical signals. The sex pheromones released by some female insects advertise their readiness to mate and can attract males from a great distance. Other pheromones act as alarm signals.

A number of pheromone traps and pheromone mating confusants are now commercially available for some insect pests. Most of the traps work by using a pheromone to attract the insect into a simple sticky trap. The mating confusants flood the area with a sex pheromone, overwhelming the males with stimuli and making it very difficult for them to pinpoint exactly where the females are.

Insect Growth Regulators (IGRs)

Immature insects produce juvenile hormones that prevent them from metamorphosing into adults. When they have grown and matured sufficiently, their bodies stop making the juvenile hormones so they can turn into adults.

Researchers have isolated and synthesized some of these chemicals and when they are sprayed on or around certain insects, these insect growth regulators prevent the pests from maturing into adults. Immature insects cannot mate and reproduce, so eventually the pest population is eliminated. These hormones do not affect us since humans and other mammals don't metamorphose as insects do.

Repellents

Some chemicals repel insects or deter them from feeding on treated plants. For example, a botanical insecticide extracted from the neem tree (*Azadirachta indica*) can prevent beetles and caterpillars from feeding on treated rose leaves. Current research shows that neem has a very low toxicity to mammals. A number of neem products are currently available but as with all pesticides, it is important to use them according to label instructions to ensure success and safety.

Desiccating Dusts

Insecticidal dusts such as diatomaceous earth and silica aerogel, made from natural materials, kill insects by absorbing the outer waxy coating that keeps water inside their bodies. With this coating gone the insects die of dehydration. Silica aerogel dust can be blown into wall voids and attics to kill drywood termites, ants, roaches, silverfish, and other crawling insects. Although these materials are not poisonous to humans directly, the fine dust travels freely through the air and can be irritating to the eyes and lungs: always use a dust mask and goggles during application.

Pesticidal Soaps and Oils

Pesticidal soaps are made from refined coconut oil and have a very low toxicity to mammals. They can be toxic to fish, so they should not be used around fishponds. Researchers have found that certain fatty acids in soaps are toxic to insects but decompose rapidly leaving no toxic residue. Soap does little damage to lady beetles and other hard-bodied insects but may be harmful to some soft-bodied beneficials. A soap-based herbicide is available for controlling seedling stage weeds; the soap kills the weeds by penetrating and disrupting plant tissue. Soap combined with sulfur is used to control common leaf diseases such as powdery mildew.

Insecticidal oils (sometimes called dormant oils or horticultural oils) also kill insects and are gentle on the environment. Modern insecticidal oils are very highly refined. Unlike the harsh oils of years ago that burned leaves and could only be used on deciduous trees during the months they were leafless, the new oils are so light they can be used to control a wide variety of insects even on many bedding plants.

Note: it as always wise to test a material on a small portion of the plant first to check for damage before spraying the entire plant.

Botanical Pesticides

Although botanical pesticides are derived from plants, they are not necessarily better or safer than synthetic pesticides. Botanicals can be easily degraded by organisms in the environment; however, plant-derived pesticides tend to kill a broad spectrum of insects, including beneficials, so they should be used with caution. The most common botanical is pyrethrum, made from crushed petals of the pyrethrum chrysanthemum flower. "Pyrethrins" are the active ingredient in pyrethrum, but "pyrethroids" have been synthesized in the laboratory, and are much more long lasting and powerful than the pyrethrins. Pyrethroids are toxic to fish and other aquatic invertebrates. Neem, another botanical pesticide, is discussed previously under "Repellents." Some botanicals, such as nicotine or sabadilla, can be acutely toxic to humans if misused, and rotenone is very toxic to fish. The same care must be used with these materials as with conventional pesticides.

5.4 How to Select a Pesticide for an IPM Program

When contemplating the use of a pesticide, it is prudent to acquire a Material Safety Data Sheet (MSDS) for the compound. MSDS forms are available from pesticide suppliers and contain some information on potential hazards and safety precautions. See **Appendix H**, the Recommended Readings section of this manual, for other reference materials on pesticides. **Appendix G,** Pesticide Information Resources, lists organizations that provide information on pesticide toxicity. You will find links to MSDS sites on the California School IPM Web site at www.schoolipm.info. Some pesticide products are exempt from the recordkeeping, notification and posting requirements of the Healthy Schools Act. Use the worksheet "Pesticides exempted from Healthy Schools Act right-to-know requirements" (**Appendix B**) to determine if a specific product is exempt. DPR's School HELPR Web page is a guide to choosing the optimal pest management action, depending on the situation.

The following criteria should be used when selecting a pesticide: safety, species specificity, effectiveness, endurance, speed, and cost.

5.4.1 Safety

This means safety for humans (especially children), pets, livestock, and wildlife, as well as safety for the overall environment. Read the pesticide label. Pesticide labels contain information to protect your health. Every label displays a "signal word" that indicates the level of acute (immediate) toxicity of the formulated pesticide product. See **Box 5-1** for explanations of the signal words. Questions to ask about safety are:

- What is the acute (immediate) and chronic (long-term) toxicity of the pesticide?

  Acute toxicity is the toxicity of the chemical after a single or limited exposure. It is measured by the lethal dose (LD50) or the lethal concentration (LC50) which causes death in 50 percent of the test animals (measured in milligrams of pesticide per kilogram of body weight of the test animal). The higher the LD50/LC50 value, the more poison it takes to kill the target animals and the less toxic the pesticide. In other words, a high LD50/LC50 value equals low toxicity. The LD50/LC50 does not reflect any effects from long-term exposure that may occur at doses below those used in short-term studies.

  Chronic toxicity refers to potential health effects from exposure to low doses of the pesticide for long periods. Chronic effects can be carcinogenic (cancer-causing), mutagenic (causing genetic changes), or teratogenic (causing birth defects). Sources of information on health effects of pesticides are provided in **Appendix G** or online at www.schoolipm.info.

- How mobile is the pesticide? Is the compound volatile, so that it moves into the air breathed by people in the building? Can it

Box 5-1: Definitions of signal words for pesticides

Federal law and the acute toxicity data determine the signal words and precautionary statements that must appear on pesticide labels (40 Code of Federal Regulations 156.10). Always read pesticide labels thoroughly before using and be sure to follow label directions. Misuse of any pesticide is not only illegal, but may create a dangerous situation.

The signal word (see below) indicates the most severe level of anticipated acute (immediate) toxicity of the formulated pesticide product to humans based on at least one of five to six tests conducted with laboratory animals. The chronic (long-term) toxicity is not indicated on the label. Note that chronic toxicity may be important for pesticide products used frequently. You can obtain chronic toxicity information from several reputable sources such as U.S. EPA (http://www.epa.gov/iriswebp/iris/index.html) or the National Pesticide Information Center (http:/npic.orst.edu). Pesticide labels typically bear the warning "Keep out of reach of children."

Signal Word	Toxicity category	Precautionary statements by toxicity category Oral, inhalation or dermal toxicity	 Skin and eye local effects
Danger — Poison Danger	I	Fatal (poisonous) if swallowed [inhaled or absorbed through skin]. Do not breathe vapors [dust or spray mist]. Do not get in eyes, on skin, or on clothing. [Front panel statement of practical treatment required]	Corrosive, causes eye and skin damage [or skin irritation]. Do not get in eyes, on skin, or on clothing. Wear goggles or face shield and rubber gloves when handling. Harmful or fatal if swallowed. [Appropriate first aid statement required].
Warning	II	May be fatal if swallowed [inhaled or absorbed through skin]. Do not breathe vapors [dust or spray mist]. Do not get in eyes, on skin, or on clothing. [Appropriate first aid statement required].	Causes eye [and skin] irritation. Do not get in eyes, on skin, or on clothing. Harmful if swallowed. [Appropriate first aid statement required].
Caution	III	Harmful if swallowed [inhaled or absorbed through skin]. Avoid breathing vapor [dust or spray mist]. Avoid contact with skin [eyes or clothing]. [Appropriate first aid statement required].	Avoid contact with skin, eyes or clothing. In case of contact, immediately flush eyes or skin with plenty of water. Get medical attention if irritation persists.
[No signal word]	IV	[No precautionary statements required]	[No precautionary statements required]

If no signal word occurs on the label, then the product has the lowest toxicity category or contains active ingredients that are exempt from federal and California registration; however, it may cause slight skin or eye irritation.

Products you select must be registered or exempted from registration*. Note that some products are neither registered nor exempted, and are, therefore, illegal to use. If chemical control is necessary, select legal products with no signal word or with caution as a signal word when available.

For information about products exempt from registration, see* **Appendix B *and California Notice to Registrants 2000-6, which is available on our Web site at* www.cdpr.ca.gov *under Programs and Services, Registration Branch.*

move through the soil into the groundwater? Does it run off in rainwater to contaminate creeks and rivers?

- What is the residual life of the pesticide? How long does the compound remain toxic in the environment?
- What are the environmental hazards listed on the label? What are the potential effects on wildlife, beneficial insects, fish, or other animals?

5.4.2 Species Specificity

The best pesticides are species-specific; that is, they affect just the group of animals or plants you are trying to suppress. Avoid broad-spectrum materials that kill many different organisms because they can kill beneficial organisms that keep pests in check. When broad-spectrum materials must be used, apply them in as selective a way as possible by spot treating.

5.4.3 Effectiveness

This issue is not as straightforward as it might seem since it depends on how effectiveness is being evaluated. For example, a pesticide can appear to be very effective in laboratory tests because it kills 99 percent of the test insects. In field tests under more realistic conditions, however, it may also kill 100 percent of the pest's natural enemies. This will lead to serious pest outbreaks later.

5.4.4 Endurance

A pesticide may have been effective against its target pest at the time it was registered, but if the pest problem is now recurring frequently, it may be a sign that the pest has developed resistance to the pesticide, in other words, that the pesticide has lost its endurance.

5.4.5 Speed

A quick-acting, short-lived, more acutely toxic material might be necessary in emergencies; a slow acting, longer lasting, less-hazardous material might be preferable for a chronic pest problem. An example of the latter is using slower-acting boric acid for cockroach control rather than a quicker-acting but more hazardous organophosphate.

5.4.6 Cost

This is usually measured as cost per volume of active ingredient used. Some of the newer, less-hazardous microbial and botanical insecticides and insect growth regulators may appear to be more expensive than some older, more hazardous pesticides. The newer materials, however, tend to be effective in far smaller doses than the older materials—one container goes a long way. This factor, together with their lower impact on the environment, often makes these newer materials more cost-effective.

5.5 Pesticide Use, Disposal, and Storage

In California, pesticide use, disposal, and storage are governed by laws in the California Food and Agricultural Code (FAC) and regulations in Title 3 of the California Code of Regulations (CCR). The laws and regulations concerning pesticide use have become increasingly complicated over the past few years. See the Pesticide Safety Information Series N in **Appendix P** for more detailed information regarding pesticide use in California schools. Pesticide applicators in schools must follow state and federal laws regarding pesticide use, disposal and storage in addition to following the requirements of the Healthy Schools Act.

Anonymous. 1991. Integrated pest management policy statement. San Diego Unified School District, Business Services Division, Plant Operation Unit, in cooperation with San Diego Environmental Health Coalition.

Anonymous. 1995. Guidelines for implementing integrated pest management program. County of Santa Clara Facility Manager's Manual.

Anonymous. 1997. The City of San Francisco integrated pest management policy. San Francisco ordinance 274-97, chapter 39.

Anonymous. 1998. Resolution of the city council of the city of Santa Cruz adopting the integrated pest management policy. Resolution No. NS-24,067.

Anonymous. 2001. Resolution for the County of Alameda establishing a policy on pesticide use and creating the Alameda County integrated pest management committee.

Anonymous. 2001. Sample school policy. Healthy Schools Campaign, Pesticide Action Kit. Californians for Pesticide Reform.

Benbrook, C., E. Groth, J.M. Halloran, M.K. Hansen, and S. Marquardt. 1996. Pest Management at the Crossroads. Consumers Union, Yonkers, NY. 272 pp.

Bio-Integral Resource Center (BIRC). 2001. 1997 Directory of Least-Toxic Pest Control Products. IPM Practitioner 23(11/12):1-39.

Boise, P., and Feeney, K. 1998. Reducing pesticides in schools: how two elementary schools control common pests using integrated pest management strategies. Community Environmental Council and Organic Consulting Services. Santa Barbara, CA. 70pp.

Boyd, S. et al. 1992. Pesticides in Our Communities: Choices for Change. Concern, Inc., Washington, D.C. 31 pp.

California Code of Regulations, Title 3. Food and Agriculture. Division 6. Pesticides and Pest Control Operations.

Cooper, S. 1990. The ABCs of non-toxic pest control. School Business Affairs (July 1990):14-17.

Daar, S. 1997. Structural IPM successes at NASA's Ames research center. IPM Practitioner 19(2):1-11.

Daar, S., Drlik, T., Olkowski, H., and Olkowski, W. 1997. IPM for Schools: a How-To Manual. Bio-Integral Resource Center, Berkeley, CA. 215 pp.

Davidson, J.A., C.F. Cornell, and D.C. Alban. 1986. The untapped alternative. American Nurseryman 167(11):99-109.

Flint, M.L., S. Daar, and R. Molinar. 2003. Establishing Integrated Pest Management Policies and Programs: a guide for public agencies. Univ. of California Statewide IPM Project.ANR Publication 8093. University of California, Davis, CA. 13 pp.

Forbes, W. 1991. From spray tanks to caulk guns: successful school IPM in Montgomery County, MD. Journal of Pesticide Reform 10(4):9-11.

Geiger, C., and Tootelian, D. 2002. 2002 Integrated Pest Management Survey of California School Districts Summary Report of Findings. Pest Management Analysis and Planning, Pest Management and Licensing Branch, Department of Pesticide Regulation. PM 03-XX. Sacramento, CA. 47 pp

Grant, J., and Woodsen, M. 2001. Community IPM for where you live, work and play. NY State IPM Program. http://www.nysipm.cornell.edu/reports/cipm_rpt01.pdf

Hembra, R.L. 1993. GAO Report to the Chairman, Subcommittee on Toxic Substances, Research and Development, Committee on Environment and Public Works, U.S. Senate Lawn Care Pesticides Reregistration Falls Further Behind and Exposure Effects Are Uncertain. U.S. General Accounting Office, Washington, D.C. 41 pp.

Johnston, G. 1984. Personal communication. IPM Coordinator, National Park Service.

Michigan State University. 1980. Pest Management Manual. Departments of Resource Development, Entomology, & Forestry, East Lansing, MI.

National Research Council. 1993. Pesticides in the Diets of Infants and Children. National Academy Press, Washington, D.C.

Olkowski, W., et al. 1976. Ecosystem management: a framework for urban pest control. Bioscience 26(6):384-389.

Olkowski, W., S. Daar, and H. Olkowski. 1991. Common-Sense Pest Control: least-toxic solutions for your home, garden, pets and community. Taunton Press, Newtown, CT. 715 pp.

Owens, J.M. and G.W. Bennett. 1983. Comparative study of German cockroach (Dictyoptera: Blattellidae) population sampling techniques. Environmental Entomology 12:1040-1046.

Pinto, L.J. and S.K. Kraft. 2000. Action Thresholds in School IPM Programs. Maryland Department of Agriculture, Pesticide Regulation Section. Annapolis, MD. 6 pp.

Raphael, D. 1997. Personal communication. Integrated Pest Management Coordinator, Department of the Environment, City and County of San Francisco, CA.

Riley, B. 1994. Getting Pesticides out of Schools. Northwest Coalition for Alternatives to Pesticides, Eugene, OR. 30pp.

Rust, M.K., J.M. Owens, and D.A. Reierson. 1995. Understanding and Controlling the German Cockroach. Oxford Univ. Press, New York. 430 pp.

Schubert, Sandra. 2001. Personal communication.

Shelley, K. 2000. The healthy schools act of 2000. California Assembly Bill No. 2260.

Simmons, S.E., Tidwell, T.E., and Barry, T.A. 1996. Overview of Pest Management Policies, Programs and Practices in Selected California School Districts. Department of Pesticide Regulation Publication PM 96-01. 60 pp.

Slater, A. Slater's Pest Control. 2001. Personal communication

Stauffer, S., Ferrentino, R., Koplinka-Loehr, C., and Sharpe, K. 1998. IPM Workbook for New York State Schools. Cornell Cooperative Extension. IPM Publication Number 605. 155pp.

Tootelian, D. 2001. 2001 IPM Baseline Survey of School Districts. Department of Pesticide Regulation. Sacramento, CA.

U.S. EPA 1993. Pest Control in the School Environment: Adopting Integrated Pest Management. Pub. No. 735-F-93-012. Office of Pesticide Programs (H7506C). Washington, D.C. 43 pp

Weir, R.J. Jr. and R.S. Fisher. 1972. Toxicologic studies on borax and boric acid. Toxicology and Applied Pharmacology. 23:351-364.

Abiotic: Nonliving component of an ecosystem, such as temperature, soil type or amount of sunlight.

Action level: The number of pests or level of pest damage that triggers a control action.

Action threshold: (see Action level)

Active ingredient: Chemicals in a pesticide formulation that are biologically active, i.e., responsible for killing or repelling the pest.

Acute toxicity: The degree to which a substance is poisonous or injurious to an organism after short-term exposure.

Adjuvant: chemicals added to a pesticide product to improve its effectiveness.

Aesthetic injury: Visually displeasing damage to plants or structures. Annoyance or embarrassment from visibility of a pest, or damage to the appearance of plants which may reduce aesthetic appeal but does not necessarily adversely affect plant health

Annual: A plant that completes its life cycle in one year and then dies.

Antimicrobial: Pesticides that are intended to disinfect, sanitize, reduce, or mitigate growth or development of microbiological organisms; or protect inanimate objects (for example floors and walls), industrial processes or systems, surfaces, water, or other chemical substances from contamination, fouling, or deterioration caused by bacteria, viruses, fungi, protozoa, algae, or slime, such as sanitizers and disinfectants. Although sanitizers and disinfectants are exempt from notification and posting requirements under the Healthy Schools Act, they are not exempt from licensed pest control business requirements to report pesticide use.

Augmentation: Releases of beneficial insects to establish or increase a natural population.

Bacillus thuringiensis: Insect pathogenic bacteria. A microbial insecticide effective against larval stages of many species of lepidoptera.

Bait: A food or other substance used to attract a pest to a pesticide or trap.

Barrier: Something material that prevents entry by pests into an area, such as screens on windows.

Beneficial insect: An insect that feeds on pest organisms.

Biennial: A plant that completes its growth in two years. The first year it produces leaves and stores food; the second year it produces fruits and seeds.

Biological control: Managing pests by using natural enemies such as predators, parasites and disease-causing organisms.

Biotic: The living components of an ecosystem, such as plants, animals and microorganisms.

Botanical pesticide: Pesticides derived from plants rather than synthesized.

Broad-spectrum: A pesticide effective against many species of pests.

Carcinogen: Any substance that can cause or aggravate cancer.

Chemical control: The use of a pesticide to reduce pest populations or activity.

Chronic toxicity: The capacity of a substance to demonstrate toxic effects as a result of repeated exposures over a period of time.

Common name: A name given to a pesticide active ingredient by a recognized committee on pesticide nomenclature

Control action threshold: Pest population level at which treatment is necessary to prevent economic loss.

Corrosive: A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact.

Crack-and-crevice treatment: As defined by the Healthy Schools Act of 2000, "the application of small quantities of a pesticide consistent with labeling instructions in a building into openings such as those commonly found at expansion joints, between levels of construction and between equipment and floors." The application of pesticides in the form of gels or pastes into cracks and crevices is exempt from the notification, posting and record keeping requirements of the Healthy Schools Act.

Cultural control: pest management practices which make the environment less favorable for pests. In schools, it involves changing people's behaviors and habits such as sanitation and garbage pickup schedules. It also refers to alterations in landscape design and installation and maintenance of grounds to reduce pest activity and damage.

Desiccating dust: A pesticide that dehydrates living tissues

Disinfectant: An agent that kills or controls vegetative forms of bacteria, molds, and mildews but does not ordinarily kill bacterial spores.

Dormant oil: An oil-based pesticide applied during the dormant stage of plant growth.

Economic injury level: Pest population level sufficient to cause economic losses greater than the cost of control.

Ecosystem: A self-sufficient habitat where living organisms and the abiotic environment continuously exchange matter and energy.

Emergency condition: As defined by the Healthy Schools Act of 2000, "any circumstances in which the school district designee deems that the immediate use of a pesticide is necessary to protect the health and safety of pupils, staff, or other persons, or the schoolsite."

EPA registration number: A number assigned to a pesticide product when U.S. EPA registers the product for use. The number must appear on all labels for the product. This number must appear on the pesticide application warning sign that must be posted when applying most pesticides on schools grounds. California uses U.S. EPA registration numbers for all products except adjuvant, which are given a California registration number.

Eradication: Control of diseases or pests by their complete elimination after introduction into a certain area.

Evapotranspiration: The total water loss from a soil by being drawn up through plant tissue and evaporated from leaf and soil surfaces.

Exclusion: A quarantine, usually defined by a legislative order, to prevent entry of certain exotic pests.

Exotic: referring to a species that is not indigenous to a region

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA): The federal law and its amendments that regulate pesticide registration and use.

Flushing: The use of an aerosol pesticide to drive a pest out of its hiding place.

Frass: The combined feces, shed skins and particles of food left by an insect pest; or the combined feces and wood fragments left by a wood-boring beetle.

Hand lens: A small, portable magnifying lens used to look at small insects.

Harborage: The hiding places or protected areas, such as cracks and crevices, which cockroaches and other pests inhabit.

Healthy Schools Act: A California right-to-know law passed in 2000 that requires all public K-12 schools to notify, post and keep records of pesticide use (see Section One for more detail).

Herbaceous: Plants having fleshy tissues rather than persistent woody tissues.

Herbicide: Pesticide to control unwanted vegetation either before or after its emergence from the ground.

Horticultural oil: Highly refined petroleum (or seed derived) oils that are manufactured specifically to control pests on plants.

Indigenous: Native to a specified area or region.

Inert ingredient: A material in a pesticide formulation that does not have anti-pest activity.

Insect growth regulator (IGR): An insecticide that interferes with insect hormones, affecting the insect's ability to develop from pupa to adult or to reproduce.

Insecticide: A substance that kills or controls insects.

Integrated pest management: As defined by the Healthy Schools Act, a pest management strategy that focuses on long-term prevention or suppression of pest problems through a combination of techniques such as monitoring for pest presence and establishing treatment threshold levels, using non-chemical practices to make the habitat less conducive to pest development, improving sanitation, and employing mechanical and physical controls. Pesticides that pose the least possible hazard and are effective in a manner that minimizes risks to people, property and the environment, are used only after careful monitoring indicates that they are needed according to pre-established guidelines and treatment thresholds. (Food and Agricultural Code section 13181)

Invertebrate: An animal without a spinal column (backbone). Examples: insects, spider, mollusks.

IPM coordinator: The school employee responsible for day-to-day interpretation of the IPM policy for a school or school system. The IPM Coordinator may or may not be a pest management professional, but is the decision-maker who receives specialized training in IPM, accesses the advice of professionals and chooses a course of action. In many districts, an IPM coordinator is equivalent to the school district designee.

IPM policy: A written document stating a school's commitment to IPM and defining overall IPM goals. This document is updated periodically, and used to guide decision-making as the IPM program is implemented.

LC50: The concentration of a substance in air that causes death in 50% of the animals exposed by inhalation. A measure of acute toxicity.

LD50: The amount of a substance which, when taken orally or absorbed through the skin, kills half of the test animals. An expression of a compound's acute toxicity.

Least hazardous: Referring to a pest management treatment that causes the least exposure or harm to humans and the environment. The pest management method, toxicity of pesticides used and exposure to the occupants are all considered.

Life cycle: The time of development of an organism from egg or birth to reproductive capacity.

Mechanical control: Pest control methods including cultivation and burning.

Metamorphosis: To change in form, as an insect does when developing from larva to adult.

Microbial control: Pest management using a pesticide whose active ingredient is a bacteria, virus, fungus, protozoa or nematode.

Monitoring: A systematic pest inspection that is conducted at regular intervals to determine the numbers of a pest, the amount of pest damage, access to food, water and harborage sites and the effectiveness of treatment methods.

Mulch: A layer of material placed on the soil surface to prevent weed growth

Mutagen: A chemical that is able to induce significant and permanent change in hereditary material thereby causing mutation in the succeeding generation.

Natural enemy: A predator or parasite that prey on or live in organisms in the natural habitat, thereby limiting their population.

Niche: An organism's place and role in its environment.

Nontarget species: Any plant, animal or other organism that may be accidentally damaged during a pesticide application.

Notification: A formal notice in writing to all parents and staff of a school district of expected pesticide use on a schoolsite.

Organic matter: A soil component resulting from the decay of plant and animal materials.

Perennial: A plant that lives from year to year.

Pest: Any living organism that interferes with or threatens human, animal or plant health, property or the environment. A pest in one environment may be beneficial in another.

Pest control: The use of any substance, method or device to prevent, destroy, repel, mitigate, or correct a pest infestation or inhibit, regulate, stimulate, or alter growth of plants (desirable or undesirable).

Pest proofing: A non-chemical, physical control measure to prevent the entry or movement of pests into or out of a structure or area. This includes sealing and caulking of crevices and holes, installation of screens, etc.

Pesticide: Any substance used to control, prevent, destroy, repel, attract or mitigate any pest. Pesticides include insecticides, insect repellents, miticides, herbicides, fungicides, fumigants, nematicides, rodenticides, avicides, plant growth regulators, defoliants, desiccants, antimicrobials, and algicides. Note: in California, adjuvants also must be registered as pesticides.

Pesticide application warning sign: A sign identifying the location, time and identity of a pesticide (including product name, manufacturer's name and the U.S. EPA's product registration number) that will be applied on a schoolsite. Signs must be posted 24 hours before a pesticide application and 72 hours afterward

Pheromone: A substance released by one organism that modifies the behavior of another of the same species. Synthetic pheromones are used in traps and lures as control or monitoring devices for some insect pests.

Physical control: Habitat alteration or changes in physical structure to reduce pest populations or their activity.

Phytotoxic: Causing injury or death to plants or portions of plants.

Population: A group of the same organisms living in a defined area.

Posting: The act of placing pesticide application warning signs in the location of a future pesticide application.

Prevention: The act of forestalling pest problems by taking actions such as sanitation.

Pyrethrins: Botanical insecticides, known collectively as pyrethrum, extracted from crysanthemums, having quick knockdown and short residual insecticidal effects.

Pyrethroid: Any of the various synthetic insecticidal compounds that are related to the pyrethrins.

Reduced-risk pesticide: a pesticides which: (1) reduce pesticide risks to human health; (2) reduce pesticide risks to non-target organisms; (3) reduce the potential for contamination of valued, environmental resources, or (4) broaden adoption of IPM or makes it more effective.

Repellent: Materials that keep pests away from plants or animals in need of protection, e.g. to protect humans from mosquitoes.

Residual pesticide: A pesticide that continues to be actively pesticidal on a treated surface or area for an extended time period after application.

Restricted use pesticide: A pesticide that can be sold to or used by only certified applicators.

Rodenticide: A pesticide used to control mice, rats, gophers and other rodents.

Runway: A path that rats and mice use to move to and from their burrows or nests. Runways usually follow along the base of a wall, building foundation or fence line.

Sanitation: Measures that promote cleanliness and pest-free surroundings. In pest management, steps taken to remove the source of a pest's food or harborage.

Sanitizer: A chemical that reduces, but does not necessarily eliminate, microorganisms from the inanimate environment to levels considered safe as determined by public health codes or regulations.

School district designee: As defined by the Healthy Schools Act of 2002, "the individual identified by the school district to carry out the requirements of this article at the schoolsite." This person may also be called the IPM Coordinator.

Schoolsite: As defined by the Healthy Schools Act, "any facility used for public day care, kindergarten, elementary, or secondary school purposes. The term includes the buildings or structures, playgrounds, athletic fields, school vehicles, or any other area of school property visited or used by pupils. "Schoolsite" does not include any postsecondary educational facility attended by secondary pupils or private day care or school facilities."

Scouting: Planned, routine monitoring for the purpose of detecting pests or pest damage.

Self-contained bait or trap: Tamper- and child-resistant bait stations whether they are for rodents, general pests, or termites.

Spot treatment: Treatment of localized or restricted patches within an area not to exceed two feet square.

Sticky trap: Traps containing a sticky substance that holds insects so they can be counted.

Teratogen: A substance or agent capable of producing or inducing functional deviations or developmental anomalies not heritable, in or on an animal embryo or fetus.

Thatch: An accumulation of partially decomposed dead stems, roots, rhizomes or leaves on the soil surface below the green top growth of turf.

Toxicity: The degree to which a material (such as a pesticide) is poisonous to an organism; the ability of a material to cause harmful, acute, delayed or allergic effects.

Transect: A sample area of vegetation usually in the form of a long continuous strip.

Vertebrate: An animal with a spinal column (backbone).

Volatile: Describing the quality in which a substance, usually a liquid, evaporates at ordinary temperatures if exposed to the air.

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Sample letter explaining annual written notification and individual application registry: For Parents

Dear Parent or Guardian,

The Healthy Schools Act of 2000 was signed into law in September 2000 and requires that all schools provide parents or guardians of students with annual written notification of expected pesticide use on school sites. The notification will identify the active ingredient or ingredients in each pesticide product and will include the Internet address (http://www.schoolipm.info/) for further information on pesticides and their alternatives. We will send out annual notifications starting ______[DATE]______.

Parents or guardians may request prior notification of individual pesticide applications at the school site. Beginning ______[DATE]______, people listed on this registry will be notified at least 72 hours before pesticides are applied. If you would like to be notified every time we apply a pesticide, please complete and return the form below and mail it to:

[SCHOOL OFFICIAL, ADDRESS]

If you have any questions, please contact

[SCHOOL OFFICIAL]
at [PHONE]

Sincerely,

[NAME OF SCHOOL PRINCIPAL]

Request for Individual Pesticide Application Notification

[NAME OF SCHOOL]

I understand that, upon request, the school district is required to supply information about individual pesticide applications at least 72 hours before application. I would like to be notified before each pesticide application at this school.

I would prefer to be contacted by (circle one): U.S. Mail E-mail Phone

Please print neatly:

Name of Parent/Guardian: ______________________________ Date: __________________

Address: ____

Day Phone:( ) __________________ Evening Phone:( ) ________________________

E-mail: ____________________________

Return to

[SCHOOL CONTACT NAME, ADDRESS]

Dear Parent or Guardian,

The Healthy Schools Act of 2000 was signed into law in September 2000 and requires that all schools provide parents or guardians of students with annual written notification of expected pesticide use on school sites. The notification will identify the active ingredient or ingredients in each pesticide product and will include the Internet address (http://www.schoolipm.info/) for further information on pesticides and their alternatives. We will send out annual notifications starting ________________.

Parents or guardians may request prior notification of individual pesticide applications at the school site. Beginning ________________, people listed on this registry will be notified at least 72 hours before pesticides are applied. If you would like to be notified every time we apply a pesticide, please complete and return the form below and mail it to:

If you have any questions, please contact

Sincerely,

Request for Individual Pesticide Application Notification

[NAME OF SCHOOL]

I understand that, upon request, the school district is required to supply information about individual pesticide applications at least 72 hours before application. I would like to be notified before each pesticide application at this school.

I would prefer to be contacted by (circle one): U.S. Mail E-mail Phone

Please print neatly:

Name of Parent/Guardian: ______________________________ Date: ____________________

Address: ____

Day Phone:( ) ____________________ Evening Phone:( ) ________________________

E-mail: ______________________________

Return to

Sample notice for specific pesticide application

Dear Parent or Guardian,

At your request, we are writing to notify you about a specific pesticide application(s) at your school. Please see below for detailed information. If you would like to see the Material Safety Data Sheet for this chemical, it is available at

[SCHOOL LOCATION]

If you have any questions, please contact

[SCHOOL DISTRICT REPRESENTATIVE NAME]
at [PHONE].

SAMPLE

Sincerely,

[NAME OF SCHOOL DISTRICT OFFICIAL]

Notice of Pesticide Application

Date Form Completed: ______________________________

School Name: ______________________________

Location of Planned Pesticide Application: ______________________________

Building Name/Number: ______________________________

Playground or Grounds Section: ______________________________

Name of Pesticide To Be Applied: ______________________________

Active Ingredient(s): ______________________________

Planned Date/Time of Pesticide Application: ______________________________

For more information regarding these pesticides and pesticide use reduction, visit the Department of Pesticide Regulation's Web site at http://www.schoolipm.info/ and click School IPM Program.

Dear Parent or Guardian,

At your request, we are writing to notify you about a specific pesticide application(s) at your school. Please see below for detailed information. If you would like to see the Material Safety Data Sheet for this chemical, it is available at

If you have any questions, please contact

Sincerely,

Notice of Pesticide Application

Date Form Completed: ____

School Name: ____

Location of Planned Pesticide Application: ______________________________

Building Name/Number: ____

Playground or Grounds Section: ______________________________________

Name of Pesticide To Be Applied: ____________________________________

Active Ingredient(s): ____

Planned Date/Time of Pesticide Application: ____________________________

For more information regarding these pesticides and pesticide use reduction, visit the Department of Pesticide Regulation's Web site at http://www.schoolipm.info/ and click School IPM Program.

Sample annual notification of planned pesticide use

Dear Parent or Guardian,

The Healthy Schools Act of 2000 requires all California school districts to notify parents and guardians of pesticides they expect to apply during the year. We intend to use the following pesticides in your school this year:

Name of Pesticide (Common Name)	Active Ingredient(s)

You can find more information regarding these pesticides and pesticide use reduction at the Department of Pesticide Regulation's Web site at http://www.schoolipm.info/

If you have any questions, please contact

[NAME OF SCHOOL DISTRICT OFFICIAL]

at [PHONE].

Dear Parent or Guardian,

The Healthy Schools Act of 2000 requires all California school districts to notify parents and guardians of pesticides they expect to apply during the year. We intend to use the following pesticides in your school this year:

Name of Pesticide (Common Name)	Active Ingredient(s)

You can find more information regarding these pesticides and pesticide use reduction at the Department of Pesticide Regulation's Web site at http://www.schoolipm.info/

If you have any questions, please contact

WARNING
PESTICIDE-TREATED AREA
ADVERTENCIA
AREA TRATADA CON PESTICIDA

Name of Pesticide
1 ____________________
2 ____________________
3 ____________________
4 ____________________

Nombre del Pesticida
1 ____________________
2 ____________________
3 ____________________
4 ____________________

Manufacturer's Name; USEPA Registration No.
1 ____________________
2 ____________________
3 ____________________
4 ____________________

Nombre del Fabricante; No. de Registro de USEPA
1 ____________________
2 ____________________
3 ____________________
4 ____________________

Intended Application Date ____________

Fecha Propuesta de Aplicacion ____________

Application Date ____________

Fecha de la Aplicacion ____________

Treated Areas; Reason for Treatment
____
____

Areas Tratada; Razon de la Aplicacion
____
____

School Name:
____

Nombre de la Escuela:
____

ALWAYS BE SAFE

1. If you need more information ask
   Name: ____________________
   Title: ____________________
2. Do not play on the treated area
3. Wash your hands and exposed skin if you touch the treated area

1. Si necesita más información pregunte
Nombre: ____________________
Título: ____________________
2. No juegue en el área tratada
3. Lávese las manos y la piel expuesta si usted toca el área tratada

For record keeping only per Education Code requirement

Amount of Pesticide Used: ____________________

APPENDIX B

Pesticides Exempt from the Healthy Schools Act Right-to-Know Requirements

Pesticides Exempt

from the School Posting, Notification, and Recordkeeping Requirements of the Healthy Schools Act of 2000 (HSA)

To determine whether a particular pesticide product is exempt from the recordkeeping, posting and notification requirements of the HSA, answer the following questions. **Exemptions notwithstanding, DPR recommends that schools keep complete records of *all* pest management activities as part of a sound integrated pest management program**.

1.) Is the product an antimicrobial (including sanitizers, disinfectants, and medical sterilants)?

Note: The federal language defining antimicrobial pesticides is attached (7 USC 136[mm]). If you can't tell from the label, you can look up specific products on DPR's website at *http://www.cdpr.ca.gov/docs/label/prodnam.htm*

YES: EXEMPT from HSA recordkeeping, posting, and notification requirements (sections 17611 and 17612)

NO: GO ON TO THE NEXT STEP

2.) Is the product a self-contained bait or trap?

Note: Pending further clarification of the law, determining whether a bait or trap is "self-contained" is the responsibility of the user.

YES: EXEMPT from HSA recordkeeping, posting, and notification requirements

NO: GO ON TO THE NEXT STEP

3.) Is the product a gel or paste deployed as crack and crevice treatments?

Notes:

- *"Gel or paste" refers to the formulation type. If in doubt, check the label or the DPR databases at* http://www.cdpr.ca.gov/docs/label/m4.htm
- *"Crack and crevice treatment" is defined under the HSA section 17608[b]* (attached).

YES: EXEMPT from HSA recordkeeping, posting, and notification requirements

NO: GO ON TO THE NEXT STEP

4.) Is the product federally registered? (That is, do you see □EPA Reg. No.□ somewhere on the label?)

YES: GO TO THE NEXT STEP

NO: If the product is not registered, there are two possibilities:

A.) *The product is illegal for use as a pesticide.*

-OR-

B.) *The product is exempt from registration under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) section 25(b), and is* ***EXEMPT from HSA recordkeeping, posting, and notification requirements.*** *(GO ON TO STEP 5 to decide if product is 25(b) exempt)*

Note: California has similar but stricter regulations on exemption from registration□ see attached 3 CCR 6147.

5.) Is the product exempt from registration under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) section 25(b)?
Note: Very few products are exempt from registration.

To find out whether the product is 25(b) exempt, check the ingredients listed on the label. All active ingredients and inert ingredients should be listed. All active ingredients must be listed as exempt in the federal regulations (see attached list of exempt active ingredients or http://www.epa.gov/pesticides/ biopesticides/otherdocs/25blist.htm), and all inert ingredients must be category "4A" inerts (see attached list of 4A inerts or http://www.epa.gov/oppbppd1/ biopesticides/otherdocs/list4adocs.htm). See 40 CFR 152.25 (attached). These federally exempt products are also exempt from California registration if the criteria outlined in California Notice to Registrants 2000-6 are met (see http://www.cdpr.ca.gov/docs/canot/ca00-6.htm).

YES: EXEMPT from HSA recordkeeping, posting, and notification requirements

NO: NOT EXEMPT. All other registered pesticide products are subject to the posting, recordkeeping, and notification requirements of the Healthy Schools Act of 2000. That is, the product is

- **not exempt from registration,**
- **legally registered at the state and federal levels,**
- **not a self-contained bait or trap,**
- **not an antimicrobial, and**
- **not a gel/paste used for crack and crevice treatments**.

Legislative text from the Healthy Schools Act of 2000 pertaining to pesticides exempted from the notification, posting, and recordkeeping requirements

17610.5. Sections 17611 and 17612 shall not apply to a pesticide product deployed in the form of a self-contained bait or trap, to gel or paste deployed as a crack and crevice treatment, to any pesticide exempted from regulation by the United States Environmental Protection Agency pursuant to the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. Sec. 25 (b)), or to antimicrobial pesticides, including sanitizers and disinfectants.

Definition of crack and crevice treatments under the Healthy Schools Act of 2000

17609. The definitions set forth in this section govern the construction of this article unless the context clearly requires otherwise:

(a) "Antimicrobial" means those pesticides defined by the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. Sec. 136(mm)).

(b) "Crack a nd crevice treatment" means the application of small quantities of a pesticide consistent with labeling instructions in a building into openings such as those commonly found at expansion joints, between levels of construction and between equipment and floors...

Definition of antimicrobial pesticides under 7 U.S.C. 136

(mm) Antimicrobial pesticide

(1) In general

The term "antimicrobial pesticide" means a pesticide that-

- (A) is intended to —
  - (i) disinfect, sanitize, reduce, or mitigate growth or development of microbiological organisms; or
  - (ii) protect inanimate objects, industrial processes or systems, surfaces, water, or other chemical substances from contamination, fouling, or deterioration caused by bacteria, viruses, fungi, protozoa, algae, or slime; and
- (B) in the intended use is exempt from, or otherwise not subject to, a tolerance under section 346a of title 21 or a food additive regulation under section 348 of title 21.

(2) Excluded products

The term "antimicrobial pesticide" does not include -

- (A) a wood preservative or antifouling paint product for which a claim of pesticidal activity other than or in addition to an activity described in paragraph (1) is made;
- (B) an agricultural fungicide product; or
- (C) an aquatic herbicide product.

(3) Included products

The term "antimicrobial pesticide" does include any other chemical sterilant product (other than liquid chemical sterilant, products exempt under subsection (u) of this section), any other disinfectant product, any other industrial microbiocide product, and any other preservative product that is not excluded by paragraph (2).

Pesticide active ingredients listed as exempt from federal registration under FIFRA 25(b).
See 40 CFR 152.25 (below) for details.

Castor oil (U.S.P. or equivalent)
Cedar oil
Cinnamon and cinnamon oil
Citric acid
Citronella and citronella oil
Cloves and clove oil
Corn gluten meal
Corn oil
Cottonseed oil
Dried blood
Eugenol
Garlic and garlic oil
Geraniol
Geranium oil
Lauryl sulfate
Lemongrass oil
Linseed oil
Malic acid
Mint and mint oil
Peppermint and peppermint oil
2-Phenethyl propionate (2-phenylethyl propionate)
Potassium sorbate
Putrescent whole egg solids
Rosemary and rosemary oil
Sesame (includes ground sesame plant) and sesame oil
Sodium chloride (common salt)
Sodium lauryl sulfate
Soybean oil
Thyme and thyme oil
White pepper
Zinc metal strips (consisting solely of zinc metal and impurities)

Pesticide inert ingredients on the U.S. EPA "4A" inert list.
See September 28, 1994 Federal Register (59 FR 49400) for details.

Acetic acid
Agar
Alfalfa
Alfalfa meal
Almond hulls
Almond shells
Alpha cellulose
Apple pomace
Attapulgite-type clay
Beef fat
Beeswax
Beet powder
Bentonite
Bone Meal
Bran
Bread crumbs
Calcareous shale
Calcite
Calcium carbonate
Canary seed
Cane syrup
Carbon dioxide
Cardboard
Carrageenan
Carrots
Casein
Cheese
Chlorophyll
Cinnamon
Citric acid
Citrus meal
Citrus pectin
Citrus pulp
Clam shells
Cloves
Cocoa
Cocoa shells
Coco shell flour
Cod liver oil
Coffee grounds
Cookies
Cork
Corn
Corn cobs
Corn flour
Corn meal
Corn oil
Cornstarch
Corn syrup
Cotton
Cottonseed meal
Cottonseed oil
Cracked oats
Cracked wheat
Dextrin
Dextrose
Dolomite
Douglas-fir bark, ground
Eggs
Egg Shells
Edible fish meal
Edible fish oil
Flour
Fuller's earth
Gelatin
Glue, as depolymerized animal collagen
Glycerin
Granite
Grape pomace
Graphite
Ground oats
Guar gum
Gum arabic
Gum tragacanth
Gypsum
Hearts of corn flour
Hydrogenated vegetable oils
Honey
Invert sugar
Invert syrup
Kaolinite-type clay
Lactose
Lanolin
Lard
Latex
Lecithin
Lime
Limestone
Linseed oil
Malt flavor
Meat meal
Meal scraps
Medicated feed
Mica
Milk
Millet seed
Mineral oil, U.S.P.
Molasses
Montmorillonite- type clay
Nitrogen
Nutria meat
Nylon
Oatmeal
Oats
Olive oil
Onions
Orange pulp
Oyster shells
Paper
Paprika
Paraffin wax
Peanut butter
Peanut oil
Peanuts
Peanut shells
Peat moss
Pecan shell flour
Pectin
Polyethylene film
Polyethylene pellets
Potatoes
Pumice
Raisins
Red cedar chips
Red dog flour
Rice
Rice hulls
Rubber
Rye Flour
Safflower oil
Sawdust
Seaweed, edible
Shale
Soapstone
Sodium bicarbonate
Sodium chloride
Sorbitol
Soybean hulls
Soybean meal
Soybean oil
Soy flour
Soy protein
Sucrose
Sugarbeet meal
Sunflower seeds
Tallow
Vanillin
Vermiculite
Vitamin C
Vitamin E
Walnut flour
Walnut shells
Water
Wheat
Wheat germ oil
Whey
Wintergreen oil
Wool
Xanthan gum
Yeast

Federal regulations pertaining to exemption from registration under FIFRA 25(b)
(40 CFR 152.25)

Code of Federal Regulations
Title 40, Volume 16

Sec. 152.25 Exemptions for pesticides of a character not requiring FIFRA regulation.

The pesticides or classes of pesticides listed in this section have been determined to be of a character not requiring regulation under FIFRA, and are therefore exempt from all provisions of FIFRA when intended for use, and used, only in the manner specified.

(a) Treated articles or substances. An article or substance treated with, or containing, a pesticide to protect the article or substance itself (for example, paint treated with a pesticide to protect the paint coating, or wood products treated to protect the wood against insect or fungus infestation), if the pesticide is registered for such use.

(b) Pheromones and pheromone traps. Pheromones and identical or substantially similar compounds labeled for use only in pheromone traps (or labeled for use in a manner which the Administrator determines poses no greater risk of adverse effects on the environment than use in pheromone traps), and pheromone traps in which those compounds are the sole active ingredient(s).

- (1) For the purposes of this paragraph, a pheromone is a compound produced by an arthropod which, alone or in combination with other such compounds, modifies the behavior of other individuals of the same species.
- (2) For the purposes of this paragraph, a synthetically produced compound is identical to a pheromone only when their molecular structures are identical, or when the only differences between the molecular structures are between the stereochemical isomer ratios of the two compounds, except that a synthetic compound found to have toxicological properties significantly different from a pheromone is not identical.
- (3) When a compound possesses many characteristics of a pheromone but does not meet the criteria in paragraph (a)(2) of this section, it may, after review by the Agency, be deemed a substantially similar compound.
- (4) For the purposes of this paragraph, a pheromone trap is a device containing a pheromone or an identical or substantially similar compound used for the sole purpose of attracting, and trapping or killing, target arthropods. Pheromone traps are intended to achieve pest control by removal of target organisms from their natural environment and do not result in increased levels of pheromones or identical or substantially similar compounds over a significant fraction of the treated area.

(c) Preservatives for biological specimens.

- (1) Embalming fluids.
- (2) Products used to preserve animal or animal organ specimens, in mortuaries, laboratories, hospitals, museums and institutions of learning.
- (3) Products used to preserve the integrity of milk, urine, blood, or other body fluids for laboratory analysis.

(d) Vitamin hormone products. Vitamin hormone horticultural products consisting of mixtures of plant hormones, plant nutrients, inoculants, or soil amendments, which meet the following criteria:

- (1) The product, in the undiluted package concentration at which it is distributed or sold, meets the criteria of Sec. 156.10(h)(1) of this chapter for Toxicity Category III or IV; and
- (2) The product is not intended for use on food crop sites, and is labeled accordingly.

(e) Foods. Products consisting of foods and containing no active ingredients, which are used to attract pests.

(f) Natural cedar.

- (1) Natural cedar blocks, chips, shavings, balls, chests, drawer liners, paneling, and needles that meet all of the following criteria:
  - (i) The product consists totally of cedarwood or natural cedar.
  - (ii) The product is not treated, combined, or impregnated with any additional substance(s).
  - (iii) The product bears claims or directions for use solely to repel arthropods other than ticks or to retard mildew, and no additional claims are made in sale or distribution. The labeling must be limited to specific arthropods, or must exclude ticks if any general term such as ‘‘arthropods,’’ ‘‘insects,’’ ‘‘bugs,’’ or any other broad inclusive term, is used. The exemption does not apply to natural cedar products claimed to repel ticks.
- (2) The exemption does not apply to cedar oil, or formulated products which contain cedar oil, other cedar extracts, or ground cedar wood as part of a mixture.

(g) Minimum risk pesticides—

(1) Exempted products. Products containing the following active ingredients are exempt from the requirements of FIFRA, alone or in combination with other substances listed in this paragraph, provided that all of the criteria of this section are met.

Castor oil (U.S.P. or equivalent)
Cedar oil
Cinnamon and cinnamon oil
Citric acid
Citronella and citronella oil
Cloves and clove oil
Corn gluten meal
Corn oil
Cottonseed oil
Dried blood
Eugenol
Garlic and garlic oil
Geraniol
Geranium oil
Lauryl sulfate
Lemongrass oil
Linseed oil
Malic acid
Mint and mint oil
Peppermint and peppermint oil
2-Phenethyl propionate (2-phenylethyl propionate)
Potassium sorbate
Putrescent whole egg solids
Rosemary and rosemary oil
Sesame (includes ground sesame plant) and sesame oil
Sodium chloride (common salt)
Sodium lauryl sulfate
Soybean oil
Thyme and thyme oil
White pepper
Zinc metal strips (consisting solely of zinc metal and impurities)

(2) Permitted inerts. A pesticide product exempt under paragraph (g)(1) of this section may only include inert ingredients listed in the most current List 4A. This list is updated periodically and is published in the Federal Register. The most current list may be obtained by writing to Registration Support Branch (4A Inerts List) Registration Division (7505C), Office of Pesticide Programs, Environmental Protection Agency, 401 M St., SW., Washington DC 20460.

(3) Other conditions of exemption. All of the following conditions must be met for products to be exempted under this section:
   (i) Each product containing the substance must bear a label identifying the name and percentage (by weight) of each active ingredient and the name of each inert ingredient.
   (ii) The product must not bear claims either to control or mitigate microorganisms that pose a threat to human health, including but not limited to disease transmitting bacteria or viruses, or claims to control insects or rodents carrying specific diseases, including, but not limited to ticks that carry Lyme disease.
   (iii) The product must not include any false and misleading labeling statements, including those listed in 40 CFR 156.10(a)(5)(i) through (viii).

[53 FR 15977, May 4, 1988, as amended at 59 FR 2751, Jan. 19, 1994; 61 FR 8878, Mar. 6, 1996]

California regulations pertaining to pesticides exempt from registration
(3 CCR 6147)

Title 3 (Food and Agricultural Code), Division 6, Chapter 2
Section 6147. Exempted Pesticide Products.

(a) Manufacturers of, importers of, and dealers in the following pesticide products or classes of pesticide products are exempt from the requirements of Division 7 of the Food and Agricultural Code, provided the pesticide products are exempt pursuant to section 25(b)(2) of the Federal Insecticide, Fungicide, and Rodenticide Act [7 U.S.C. sec. 136w(b)(2)]:

(1) Pheromones and identical or substantially similar compounds labeled for use only in pheromone traps (or labeled for use in a manner which the Director determines poses no greater risk of adverse effects on the environment than use in pheromone traps), and pheromone traps in which those compounds are the sole active ingredient(s), as specified in 40 Code of Federal Regulations 152.25(b).

(2) Preservatives for biological specimens, including:

(A) Embalming fluids;

(B) Products used to preserve animal or animal organ specimens, in mortuaries, laboratories, hospitals, museums and institutions of learning; and

(C) Products used to preserve the integrity of milk, urine, blood, or other body fluids for laboratory analysis.

(3) Products consisting of foods that are used to attract pests and which contain no active ingredient(s).

(4) (A) Natural cedar blocks, chips, shavings, balls, chests, drawer liners, paneling, and needles that meet all of the following criteria:

1. The product consists totally of cedar wood or natural cedar.
2. The product is not treated, combined, or impregnated with any additional substance(s).
3. The product bears claims or directions for use solely to repel arthropods other than ticks or to retard mildew, and no additional claims are made in sale or distribution. The labeling must be limited to specific arthropods, or must exclude ticks if any general term such as "arthropods," "insects," "bugs," or any other broad inclusive term is used.

(B) The exemption does not apply to natural cedar products claimed to repel ticks. The exemption also does not apply to cedar oil, or formulated products, which contain cedar oil, other cedar extracts, or ground cedar wood as part of a mixture.

(5) (A) Products containing the following active ingredients alone or in combination with other substances listed in paragraph (5)(A), provided that all the criteria specified in paragraphs (5)(C) and (5)(D) are met:

Castor oil (U.S.P. or equivalent)
Cedar oil [1]
Cinnamon
Cinnamon oil [1]
Citric acid [1]
Citronella (non-topical uses only)
Citronella oil (non-topical uses only)
Cloves [2]
Clove oil [1, 2]
Corn gluten meal
Corn oil
Cottonseed oil
Dried blood
Eugenol [1, 2]
Garlic
Garlic oil [1]
Geraniol [2]
Geranium oil [2]
Lauryl sulfate [1]
Lemongrass oil [1]
Linseed oil
Malic acid [1]
Mint

Mint oil [1]
Peppermint [2]
Peppermint oil [1, 2]
2-Phenethyl propionate (2-phenylethyl propionate) [1]
Potassium sorbate [1]
Putrescent whole egg solids
Rosemary [2]
Rosemary oil [1, 2]
Sesame (includes ground sesame plant)
Sesame oil
Sodium chloride (common salt)
Sodium lauryl sulfate [1, 2]
Soybean oil
Thyme [2]
Thyme oil [1, 2]
White pepper [1]
Zinc metal strips (consisting solely of zinc metal and impurities)

[1] Products containing 8.5% or more of this active ingredient in the formulated product must at a minimum bear the signal word "CAUTION," the phrase "Keep Out of Reach of Children," appropriate precautionary language, and a requirement for appropriate protective eyewear and gloves.

[2] Products containing this active ingredient intended for topical application to human skin must at a minimum bear the signal word "CAUTION," the phrase "Keep Out of Reach of Children," a dermal sensitization precautionary statement, a prohibition against application to the hands of children, and use directions requiring adult supervision during application to children.

(B) Topical use products containing less than or equal to 1% of the following active ingredients alone or in combination with each other, provided: the product label carries as a minimum the signal word "CAUTION," the phrase "Keep Out Of Reach of Children," a dermal sensitization precautionary statement, a prohibition against application to the hands of children, and use directions requiring adult supervision during application to children, and (ii) all the criteria specified in paragraphs (5)(C) and (5)(D) are met:
Citronella
Citronella oil

(C) A pesticide product exempt under paragraphs (5)(A) and (5)(B) of subsection (a) may include as inert ingredients only those substances listed in the U.S. Environmental Protection Agency□s most current List 4A "Inerts of Minimal Concern." U.S. EPA□s list of minimal risk inert ingredients is updated periodically and is published in the Federal Register.

(D) In addition, all of the following conditions must be met for products to be exempted under subsection (a)(5):
1. Each product containing the substance must bear a label identifying the name and percentage (by weight) of each active ingredient and the name of each inert ingredient.
2. The product must not bear claims either to control or mitigate microorganisms that pose a threat to human health, including but not limited to disease transmitting bacteria or viruses, or claims to control insects or rodents carrying specific diseases, including, but not limited to ticks that carry Lyme disease.
3. The product must not include any false and misleading labeling statements, including those listed in 40 CFR 156.10(a)(5)(i) through (viii).

(b) Whenever the manufacturer of, importer of, or dealer in any product exempted pursuant to this section has factual or scientific evidence of any adverse effect or risk to human health or the environment that has not previously been submitted to the department, the manufacturer, importer, or dealer shall report the evidence to the department within 60 days of learning of the information.

NOTE: Authority cited: Section 11456, 12781, and 12803, Food and Agricultural Code.
Reference: Section 12803, Food and Agricultural Code.

APPENDIX C

California Youth Authority Guidelines

State of California Department of Health Services

M e m o r a n d u m

Date: August 27, 2001

To: John Brady, CHSA II
Department of the Youth Authority

From: Paul Fitzmaurice
Environmental Specialist IV
Institutions Program

Subject: Implementation of Healthy Schools Act-Youth Authority

In response to our recent conversation regarding the implementation of the Healthy Shools Act by the Youth Authority, we contacted representatives of the Department of Pesticide Regulation and the Department of Education and discussed the matter.

The law, designed to change pest control practices at schools to incorporate the least toxic means of control includes a section [Education Code, Article 4, Chapter 5, Part 10.5, Section 17612 (e)] in which California Youth Authority schools are instructed what measures are required to be taken by Youth Authority facilities to comply with the Act.

Specifically, the school administator is required to notify the chief medical officer (CMO) of the facility at least 72 hours prior to application of pesticides and the CMO is required to take all steps necessary to protect the health of the pupils in that facility. Guidelines were not developed to clarify this "all steps necessary".

After consultation with affected agencies, we recommend that the following action be taken by Youth Authority facilities to comply with the Act. These measures, in our opinion, would be considered reasonable and would provide the required protection to the wards at the facility.

- The CMO of each facility should receive a list of all pesticides that would be anticipated to be used in the facility during the calendar year. Attached to the list should be a copy of the product label (or product EPA registration number), and the Material Safety Data Sheet (MSDS) for each item on the list. [California Code of Regulations (CCR), Title 3, Division 6, Chapter 3, section 6723]

- Existing law [Food and Agricultural Code (FAC), section 12973] requires any user of a pesticide to comply with the label.

- Existing law CCR, sections 6618, 6624 & 6627 detail notification, pesticide use records, and reporting requirements for licensed Pest Control Businesses (PCB), while FAC, section 13186 requires specific pesticide use information for school site applications by PCBs. Also, staff assigned pest control duties and contracted pest control companies should provide the CMO 72-hour notice of specific pest control applications.

- The yearly list of pesticides anticipated to be used should be posted at the entry to the facility and a copy should be provided to all staff members.
- Existing regulations require employers to have a written training program and to assure employees are trained before handling any pesticide. [CCR, section 6724] Staff responsible for pest control applications should contact the local County Agricultural Commissioner's (CAC) Office for assistance with determining applicable pesticide regulations. Staff responsible for pest control applications should keep detailed records of material used (including product EPA registration number), amount used, application locations, pests controlled, and date of application.
- The CMO should thoroughly investigate any complaint or suspected illness due to application of a pesticide and take appropriate action (e.g. filing of pesticide illness report with local CAC).
- The purpose of the law is to reduce the use of toxic pesticides at a school site; facilities may wish to institute policies to stress integrated pest management (IPM) practices and to reduce the use of pesticides when such measures as sanitation and exclusion can help to achieve the desired control. Also, if a CMO reviews label and MSDS information (as well as accessing the Department of Pesticide Regulation's "School IPM" Web site at www.cdpr.ca.gov/docs/schoolipm) and determines that the use of a material presents an unacceptable risk or is inappropriate for the situation he/she should restrict its use.

It should be noted that the law exempts products that are deployed as self-contained baits or traps, gels or pastes deployed as "crack or crevice" treatments, and pesticides that are exempt from federal regulations, or to anti-microbial pesticides, including sanitizers and disinfectants.

If you have any questions please contact Mark Jeude at (916) 323-2758 or me at (916) 445-4409.

John Brady

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August 27, 2001

APPENDIX D

Text of the Healthy Schools Act of 2000

(Chapter 718, Stautes of 2000)

Assembly Bill No. 2260

CHAPTER 718

An act to add Section 48980.3 to, and to add Article 4 (commencing with Section 17608) to Chapter 5 of Part 10.5 of, the Education Code, and to add Article 17 (commencing with Section 13180) to Chapter 2 of Division 7 of the Food and Agricultural Code, relating to school safety.

[Approved by Governor September 25, 2000. Filed with Secretary of State September 27, 2000.]

LEGISLATIVE COUNSEL'S DIGEST

AB 2260, Shelley. School safety.

Under existing law, the Department of Pesticide Regulation has primary responsibility for enforcing pesticide laws and regulations. Existing law establishes and maintains various programs to promote health and prevent disease.

This bill would establish the Healthy Schools Act of 2000. The bill would require that the preferred method of managing pests at schoolsites be effective least toxic pest management practices and would further require that the state take the necessary steps, pursuant to specified provisions, to facilitate the adoption of effective least management practices at schoolsites. The bill would require each schoolsite to maintain records of all pesticide use at the schoolsite for a period of 4 years and make the records available to the public upon request, thus imposing a state-mandated local program. The bill would require that licensed and certified pest control operators include information on any school pesticide application that they perform as part of their otherwise applicable pesticide use reporting requirements.

The bill would require, on an annual basis, the school district designee to provide to all staff and parents or guardians of pupils enrolled at a school written notification addressing, among other things, expected pesticide use, thus imposing a state-mandated local program. The bill would require that the recipients be afforded the opportunity to register with the school district to receive information regarding individual pesticide applications. The bill would require the school district designee to post warning signs prior to application of pesticides at a schoolsite, thus imposing a state-mandated local program.

The bill would require the Department of Pesticide Regulation to promote and facilitate the voluntary adoption of integrated pest management programs as specified, maintain an internet website, and establish an integrated pest management training program. The bill would provide definitions of terms for the Healthy Schools Act of 2000.

The California Constitution requires the state to reimburse local agencies and school districts for certain costs mandated by the state. Statutory provisions establish procedures for making that reimbursement, including the creation of a State Mandates Claims Fund to pay the costs of mandates that do not exceed $1,000,000 statewide and other procedures for claims whose statewide costs exceed $1,000,000.

This bill would provide that, if the Commission on State Mandates determines that the bill contains costs mandated by the state, reimbursement for those costs shall be made pursuant to these statutory provisions.

The people of the State of California do enact as follows:

SECTION 1. Article 4 (commencing with Section 17608) is added to Chapter 5 of Part 10.5 of the Education Code, to read:

Article 4. Healthy Schools Act of 2000

17608. This article, Article 17 (commencing with Section 13180) of Chapter 2 of Division 7 of the Food and Agricultural Code, and Article 2 (commencing with Section 105500) of Chapter 76 of Division 103 of the Health and Safety Code, shall be known and cited as the Healthy Schools Act of 2000.

17609. The definitions set forth in this section govern the construction of this article unless the context clearly requires otherwise:

(a) ‘‘Antimicrobial’’ means those pesticides defined by the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. Sec. 136(mm)).

(b) ‘‘Crack and crevice treatment’’ means the application of small quantities of a pesticide consistent with labeling instructions in a building into openings such as those commonly found at expansion joints, between levels of construction and between equipment and floors.

(c) ‘‘Emergency conditions’’ means any circumstances in which the school district designee deems that the immediate use of a pesticide is necessary to protect the health and safety of pupils, staff, or other persons, or the schoolsite.

(d) ‘‘School district designee’’ means the individual identified by the school district to carry out the requirements of this article at the schoolsite.

(e) ‘‘ Schoolsite’’ means any facility used for public day care, kindergarten, elementary, or secondary school purposes. The term includes the buildings or structures, playgrounds, athletic fields, school vehicles, or any other area of school property visited or used by pupils. ‘‘Schoolsite’’ does not include any postsecondary educational facility attended by secondary pupils or private day care or school facilities.

17610. It is the policy of the state that effective least toxic pest management practices should be the preferred method of managing pests at schoolsites and that the state, in order to reduce children's exposure to toxic pesticides, shall take the necessary steps, pursuant to Article 17 (commencing with Section 13180) of Chapter 2 of Division 7 of the Food and Agricultural Code, to facilitate the adoption of effective least toxic pest management practices at schoolsites. It is the intent of the Legislature to encourage appropriate training to be provided to school personnel involved in the application of pesticide at a schoolsite.

17610.5. Sections 17611 and 17612 shall not apply to a pesticide product deployed in the form of a self-contained bait or trap, to gel or paste deployed as a crack and crevice treatment, to any pesticide exempted from regulation by the United States Environmental Protection Agency pursuant to the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. Sec. 25 (b)), or to antimicrobial pesticides, including sanitizers and disinfectants.

17611. Each schoolsite shall maintain records of all pesticide use at the schoolsite for a period of four years, and shall make this information available to the public, upon request, pursuant to the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1 of the Government Code). A schoolsite may meet the requirements of this section by retaining a copy of the warning sign posted for each application required pursuant to Section 17612, and recording on that copy the amount of the pesticide used.

17612. (a) The school district designee shall annually provide to all staff and parents or guardians of pupils enrolled at a schoolsite a written notification of the name of all pesticide products expected to be applied at the school facility during the upcoming year. The notification shall identify the active ingredient or ingredients in each pesticide product. The notice shall also contain the Internet address used to access information on pesticides and pesticide use reduction developed by the Department of Pesticide Regulation pursuant to Section 13184 of the Food and Agricultural Code and may contain other information deemed necessary by the school district designee. No other written notification of pesticide applications shall be required by this act except as follows:

(1) In the written notification provided pursuant to this subdivision, the school district designee shall provide the opportunity for recipients to register with the school district if they wish to receive notification of individual pesticide applications at the school facility. Persons who register for such notification shall be notified of

individual pesticide applications at least 72 hours prior to the application. The notice shall include the product name, the active ingredient or ingredients in the product, and the intended date of application.

(2) If a pesticide product not included in the annual notification is subsequently intended for use at the schoolsite, the school district designee shall, consistent with this subdivision and at least 72 hours prior to application, provide written notification of its intended use.

(b) The school designee shall make every effort to meet the requirements of this section in the least costly manner. Annual notification to parents and guardians shall be provided pursuant to Section 48980.3. Any other notification shall, to the extent feasible and consistent with the act adding this article, be included as part of any other written communication provided to individual parents or guardians. Nothing in this section shall require the school district designee to issue the notice through first-class mail, unless he or she determines that no other method is feasible.

(c) Pest control measures taken during an emergency condition as defined in Section 17609 shall not be subject to the requirements of paragraphs (1) and (2) of subdivision (a). However, the school district designee shall make every effort to provide the required notification for an application of a pesticide under emergency conditions.

(d) The school district designee shall post each area of the schoolsite where pesticides will be applied with a warning sign. The warning sign shall prominently display the term ‘‘Warning/Pesticide Treated Area’’ and shall include the product name, manufacturer’s name, the United States Environmental Protection Agency’s product registration number, intended date and areas of application, and reason for the pesticide application. The warning sign shall be visible to all persons entering the treated area and shall be posted 24 hours prior to the application and remain posted until 72 hours after the application. In case of a pest control emergency, the warning sign shall be posted immediately upon application and shall remain posted until 72 hours after the application.

(e) Subdivisions (a) and (d) shall not apply to schools operated by the California Youth Authority. The school administrator of a school operated by the California Youth Authority shall notify the chief medical officer of that facility at least 72 hours prior to application of pesticides. The chief medical officer shall take any steps necessary to protect the health of pupils in that facility.

(f) This section and Section 17611 shall not apply to activities undertaken at a school by participants in the state program of agricultural vocational education, pursuant to Article 7 (commencing with Section 52450) of Chapter 9 of Part 28, if the activities are necessary to meet the curriculum requirements prescribed in Section 52454. Nothing in this subdivision relieves schools participating in the state program of agricultural vocational education of any duties pursuant to this section for activities that are not directly related to the curriculum requirements of Section 52454.

17613. Section 17612 shall not apply to any agency signatory to a cooperative agreement with the State Department of Health Services pursuant to Section 116180 of the Health and Safety Code.

SEC. 2. Section 48980.3 is added to the Education Code, to read:

48980.3. The notification required pursuant to Section 48980 shall include information regarding pesticide products as specified in subdivision (a) of Section 17612.

SEC. 3. Article 17 (commencing with Section 13180) is added to Chapter 2 of Division 7 of the Food and Agricultural Code, to read:

Article 17. Healthy Schools Act of 2000

13180. This article, Article 4 (commencing with Section 17608) of Chapter 5 of Part 10.5 of the Education Code, and Article 2 (commencing with Section 105500) of Chapter 7 of Division 103 of the Health and Safety Code, shall be known and may be cited as the Healthy Schools Act of 2000.

13181. Notwithstanding any other provision of law, for purposes of this article, ‘‘integrated pest management’’ means a pest management strategy that focuses on long-term prevention or suppression of pest problems through a combination of techniques such as monitoring for pest presence and establishing treatment threshold levels, using nonchemical practices to make the habitat less conducive to pest development, improving sanitation, and employing mechanical and physical controls. Pesticides that pose the least possible hazard and are effective in a manner that minimizes risks to people, property, and the environment, are used only after careful monitoring indicates they are needed according to preestablished guidelines and treatment thresholds. This definition shall apply only to integrated pest management at school facilities.

13182. It is the policy of the state that effective least toxic pest management practices should be the preferred method of managing pests at schoolsites and that the state, in order to reduce children’s exposure to toxic pesticides, shall take the necessary steps, pursuant to this article, to facilitate the adoption of effective least toxic pest management practices at schoolsites. It is the intent of the Legislature to encourage appropriate training to be provided to school personnel involved in the application of pesticide at a schoolsite.

13183. The Department of Pesticide Regulation shall, by July 1, 2001, promote and facilitate the voluntary adoption of integrated pest management programs for all school districts that voluntarily choose to do so. For these school districts, the department shall do all of the following:

(a) Establish an integrated pest management program for school districts consistent with Section 13181. In establishing the program, the department shall:

(1) Develop criteria for identifying least-hazardous pest control practices and encourage their adoption as part of an integrated pest management program at each schoolsite.

(2) Develop a model program guidebook that prescribes essential program elements for a school district that has adopted a least-hazardous integrated pest management program. At a minimum, this guidebook shall include guidance on all of the following:

(A) Adopting an IPM policy.

(B) Selecting and training an IPM coordinator.

(C) Identifying and monitoring pest populations and damage.

(D) Establishing a community-based school district advisory committee.

(E) Developing a pest management plan for making least-hazardous pest control choices.

(F) Contracting for integrated pest management services.

(G) Training and licensing opportunities.

(H) Establishing a community-based right-to-know standard for notification and posting of pesticide applications.

(I) Recordkeeping and program review.

(b) Make the model program guidebook available to school districts and establish a process for systematically updating the guidebook and supporting documentation.

13184. (a) In implementing Section 13183, the department shall establish and maintain an Internet website as a comprehensive directory of resources describing and promoting least-hazardous practices at schoolsites. The website shall also make available an electronic copy of the model program guidebook, its updates, and supporting documentation. The department shall also establish and maintain on its website an easily identified link that provides the public with all appropriate information regarding the public health and environmental impacts of pesticide active ingredients and ways to reduce the use of pesticides at school facilities.

(b) It is the intent of the Legislature that the state assist school districts to ensure that compliance with Section 17612 of the Education Code is simple and inexpensive. The department shall include in its website Internet-based links that allow schools to properly identify and list the active ingredients of pesticide products they expect to be applied during the upcoming year. Use of these links by schools is not mandatory but shall be made available to all schools at no cost. The department shall ensure that adequate resources are available to respond to inquiries from school facilities or districts regarding the use of integrated pest management practices.

13185. (a) The department shall establish an integrated pest management training program in order to facilitate the adoption of a model IPM program and least-hazardous pest control practices by school districts. In establishing the IPM training program, the department shall do all of the following:

(1) Adopt a ‘‘train-the-trainer’’ approach, whenever feasible, to rapidly and broadly disseminate program information.

(2) Develop curricula and promote ongoing training efforts in cooperation with the University of California and the California State University.

(3) Prioritize outreach on a regional basis first and then to school districts.

(b) Nothing in this article shall preclude a school district from adopting stricter pesticide use policies.

13186. (a) The Legislature finds and declares that the Department of Pesticide Regulation, pursuant to Section 12979 of the Food and Agricultural Code and Sections 6624 and 6627 of Title 3 of the California Code of Regulations, requires persons engaged for hire in the business of pest control to maintain records of pesticide use and report a summary of that pesticide use to the county agricultural commissioner or director. The Legislature further finds and declares that it is in the interest of the state, in implementing a school integrated pest management program pursuant to this article, to collect specified information on the use of pesticides at school facilities.

(b) The Department of Pesticide Regulation shall prepare a school pesticide use form to be used by licensed and certified pest control operators when they apply any pesticides at a schoolsite. The form shall include, for each application at a schoolsite, the name and address of the schoolsite, date and location of application, pesticide product name, and the quantity of pesticide used. Nothing in this section shall change any existing applicable pesticide use reporting requirements.

(c) On and after January 1, 2002, persons required to submit pesticide use records to the county agricultural commissioner or director shall complete and submit to the director the school pesticide use forms established pursuant to this section. The forms shall be submitted annually and may be submitted more often at the discretion of the pest control operator maintaining the forms.

13187. Section 13186 shall not apply to any agency signatory to a cooperative agreement with the State Department of Health Services pursuant to Section 116180 of the Health and Safety Code.

13188. The Director of Pesticide Regulation may adopt regulations to implement this article.

SEC. 4. Notwithstanding Section 17610 of the Government Code, if the Commission on State Mandates determines that this act contains costs mandated by the state, reimbursement to local agencies and school districts for those costs shall be made pursuant to Part 7 (commencing with Section 17500) of Division 4 of Title 2 of the Government Code. If the statewide cost of the claim for reimbursement does not exceed one million dollars ($1,000,000), reimbursement shall be made from the State Mandates Claims Fund.

O

Model School IPM Policy

This policy is based on IPM. It does not prohibit pesticide use. IPM does not exclude the use of pesticides, but it does encourage minimizing their use and using those that pose the least hazard. This language may be used as it appears here or it may be adapted. Some IPM policies are long and very detailed; others are more succinct. Samples in use in some California schools follow this model policy. The examples policies included are a fraction of the model policies in use by California schools. See our Web site at http:/ www.schoolipm.info/ for more examples.

Introduction

The {insert name} School District recognizes that maintenance of a safe, clean and healthful environment for students and staff is essential to learning. It is the goal of the District to provide safe and effective, pest control while protecting students, staff, the environment, and District properties and assets.

The District adopts a Least-Hazardous Integrated Pest Management (IPM) Policy. It is the policy of the District to focus and develop long-term pest prevention methods and give "non-chemical" methods first consideration when selecting appropriate control measures. The full range of alternatives will be considered, giving preference to non-chemical methods, and then chemicals that pose the least hazard to people and the environment.

Comment: This paragraph states the intention of the district to adopt IPM.

Pest management objectives

Pests will be controlled to protect the health and safety of the students and staff; to maintain a productive learning environment; and, to maintain the integrity of the school buildings and grounds. Pest control will be economically feasible over the long term and efficacious. The Superintendent or designee shall ensure that the district follows IPM procedures so as to use the most appropriate and least-hazardous method of control. Sanitary measures shall be enforced and buildings regularly cleaned and repaired in order to prevent infestations, minimize the use of pesticides, and eliminate routine spraying.

Comment: This paragraph states that, to protect human health and environmental safety, the district plans to prevent pest infestations through sanitation and other practices consistent with IPM methods, and to eliminate routine spraying. It also notes that pest control should be economically feasible.

Definition of IPM

The Healthy Schools Act of 2000 defines IPM as "a pest management strategy that focuses on long-term prevention or suppression of pest problems through a combination of techniques such as monitoring for pest presence and establishing treatment threshold levels, using non-chemical practices to make the habitat less conducive to pest development, improving sanitation, and employing mechanical and physical controls. Pesticides that pose the least possible hazard and are effective in a manner that minimizes risks to people, property and the environment, are used only after careful monitoring indicates that they are needed according to pre-established guidelines and treatment thresholds." (Food and Agricultural Code section 13181)

Comment: This section defines IPM according to the Healthy Schools Act.

Elements of the Least-Hazardous IPM Policy

- Identifying and monitoring pests to determine pest population levels and identify decisions and practices that could affect pest populations.
- Setting of action levels to determine when vegetation or a pest population at a specific site cause(s) unacceptable economic or medical damage wherein corrective action should be taken.
- Modifying and/or eliminating pest habitats to deter pest populations and minimize pest infestations.
- Considering use of a range of potential treatments for the pest problem, including physical, horticultural, and biological methods of pest control.
- Using chemical controls only as a last resort, and only those chemicals that pose the least possible hazard to people and the environment.

Comment: Monitoring, and the other elements listed, are keystones of IPM and should be an integral part of pest management procedures.

Decision-Making Process

IPM Committee

The District shall establish an IPM Committee to provide guidance, education and advice regarding implementation of the IPM policy. The committee will review and approve the IPM Coordinator's plan and recommendations to the School Board regarding all pest management practices. The Superintendent will appoint members of the committee which will be comprised of at least the following: Superintendent or designee, one member of the Board of Trustees, the IPM Coordinator, a parent of District-enrolled student(s) and one community member at large.

Comment: This committee can be very useful in making suggestions, doing research, and bringing in new information, but it need not have authority to make policy. It is helpful if the committee also has an independent pest management expert (preferably one trained in IPM). Having a teacher and/or principal from the district can also be helpful.

IPM Coordinator

The Superintendent shall designate a staff person to coordinate the IPM program. The IPM coordinator shall be educated in the principles and practice of least-hazardous IPM and be responsible for:

- Oversight for the successful implementation of the program consistent with this policy and coordinate all District efforts to adopt IPM.
- Overall program management and providing proposed regulations or procedures and products for use in managing pest populations.
- Formal annual notification to parents, staff and students of any chemical pesticide application not exempt from requirements of the Healthy Schools Act.
- Posting warning signs for pesticide applications.
- Establishing and maintaining a registry of parents, staff and students who have indicated that they desire prior notification of each pesticide application.
- Recordkeeping guidelines for any chemical pesticide application.
- Education and training for IPM personnel.
- *Optional: A list of approved procedures and products.*

Comment: The Healthy Schools Act requires school districts to designate a person to carry out the provisions of the law. If the district chooses to adopt IPM, this person may be called the IPM Coordinator. An IPM program will work more smoothly if someone has the job of coordinating its various elements. See also section 2.6 of this guidebook for more information on selecting and training an IPM Coordinator.

Training

Training of personnel is critical to the success of an IPM program. Staff, students, pest managers and the public shall be educated about potential school pest problems, the IPM Policy, and procedures that will be used to achieve the desired pest management objectives. Within five months of district adoption of this policy, the IPM Committee will agree on a plan to educate and train these constituencies.

Comment: Training must be included in an IPM program so that staff and students understand the changes that will be taking place, and so that personnel that must deal directly with pest management can easily secure information, tools, and techniques that will help them make the transition to IPM.

Contractors

All pest control companies contracted by the District shall follow all provisions of the policy. Licensed and certified pest control operators are required to include information on any school pesticide application that they perform as part of their otherwise applicable reporting requirements.

Comment: This paragraph states that contractors will use pest management practices consistent with IPM methods, and their pesticide use reporting will conform with the Healthy School Act requirements.

Notification, Recordkeeping and Reporting

Annual notification

The District shall annually provide to all staff, parents or guardians of pupils, enrolled at a school site, a written notification of all pesticide products to be used during the upcoming year. The notice shall identify the ingredients in each pesticide. The notice shall also contain the Internet address used to access information on pesticides and pesticide use reduction developed by the Department of Pesticide Regulation pursuant to Section 13184 of the Food and Agriculture Code.

Individual notification of pesticide application

The annual written notification shall provide the opportunity for recipients to receive notification of individual pesticide application at the school facility. The designee shall notify persons who register for such notification of individual pesticide applications at least 72 hours prior to the application. The notice shall include the product name, the active ingredients and the intended date of application.

Posting pesticide applications

The District designee shall post warning signs at each area to be treated. The sign shall include the term "Warning/Pesticide Treated Area," the product name, manufacturers name, the EPA product registration number, date of application, area of application and the target pest. These signs shall be posted 24 hours prior to the application and remain for 72 hours after the application.

Posting approved & banned product lists {optional, see next page}

Application records

Each school site shall maintain records of pesticide use for a period of 4 years. This requirement can be met by retaining a copy of the posting sign for individual applications. These records shall be made available to the public upon request, pursuant to the California Public Records Act. (Legal Reference: Education Code, section 17611)

Emergency pesticide applications

Pest control measures taken during an emergency, i.e., wherein the school district designee deems that the immediate use of a pesticide is necessary to protect the health and safety of pupils, staff or other persons, or the school site, shall not be subject to the notification requirements herein. However, the District designee shall make every effort to provide the required notification for an application of a pesticide under emergency conditions.

Exemptions from Notification, Recordkeeping and Reporting

Some pesticide products are exempt from notification, recordkeeping and reporting requirements. Pesticide products used as a self-contained bait or trap, gel or paste deployed as a crack and crevice treatment, any pesticide exempted under FIFRA (7 U.S.C. Sec. 25 (b)), or antimicrobial pesticides, including sanitizers and disinfectants, are exempt.

Comment: This section outlines requirements of the Healthy Schools Act that all schools must implement. Notification, posting and recordkeeping addresses the public's right-to-know. In addition, written records serve as the memory of an IPM program; thus, documenting all pest management action is very important.

Optional: Product Selection and Use Approval

Some districts have also included in their policy an additional section on Product Selection and Use Approval. Examples of these sections can be found in the Oakland Unified and Kentfield school district policies that follow.

Kentfield School District
Least-Toxic Integrated Pest Management Policy

The Kentfield School District ("District") recognizes that maintenance of a safe, clean and healthful environment for students and staff is essential to learning. It is the goal of the District to provide for the safest and lowest risk approach to control pest problems while protecting students, staff, the environment, and District property.

The District adopts a Least-Toxic Integrated Pest Management (IPM) Policy. Pests and weeds will be controlled: to protect the health and safety of students and staff; to maintain a productive learning environment; and, to maintain the integrity of school buildings and grounds. It is the policy of the District to focus on long-term pest prevention and give non-chemical methods first consideration when selecting appropriate control techniques. The full range of alternatives will be considered, giving preference to no use of chemicals and then chemicals that pose the least possible hazard to people and the environment.

A Least-Toxic Integrated Pest Management (IPM) policy contains the following elements:

1. Monitoring to determine pest population levels and identify decisions and practices that could affect pest populations.
2. Setting of injury and action levels to determine when vegetation or a pest population at a specific site cause(s) unacceptable economic or medical damage wherein corrective action should be taken.
3. Modification of pest habitats to deter pest populations and minimize pest infestations.
4. Consideration of a range of potential treatments for the pest problem, including physical, horticultural, and biological methods of pest control, using synthetic chemical controls only as a last resort and only those chemicals that pose the least possible hazard to people and the environment. Without prior approval by the Board, in an emergency, the District will not use any Toxicity Category I or Toxicity Category II Pesticide product, any pesticide product containing an ingredient known to the State of California to cause cancer, developmental toxicity, or reproductive toxicity, pursuant to the California Safe Drinking Water and Toxic Enforcement Act of 1986, or any pesticide product containing an ingredient classified by the United States Environmental Protection Agency as a known, possible or probable human carcinogen, reproductive toxin, developmental toxin or known possible or probable endocrine disrupter.

The Superintendent shall designate a staff person to coordinate the IPM program. The IPM coordinator shall be educated in the principles and practice of least toxic IPM and be responsible for:

1. Recommending a plan to the Board in July for the following school year. Included in this plan will be:

- ■ Overall turf management and facilities plan listing all proposed products and methods proposed for use

- ■ Procedures for formal notification to parents, staff and students of any chemical pesticide application which will include pre-and-post signage and written notice

- ■ Recordkeeping guidelines for any chemical pesticide application

- ■ Education and training for IPM personnel

- ■ List of products on an Approved List, Limited Use and Use Banned and a process to make exceptions in case of emergency to use a product not on the Approved List.

2. Overseeing implementation of the program consistent with this policy and coordinating all District efforts to adopt IPM.

3. Tracking all pesticide use and ensuring that records of pesticide use are made available to the public.

4. Presenting an annual report in June to the School Board evaluating the progress of the IPM program.

Business BP 3514

PESTICIDE MANAGEMENT PRACTICES— Policy

Policy Statement

Pest Management

Integrated Pest Management Policy

The IPM Coordinator and Annual IPM Plan

IPM Committee

Notification

Legal References

Policy Statement

The Governing Board believes that students and employees have the right to learn and work in a safe, clean and healthy environment. The District has an obligation to locate and reduce or eliminate potential risks to health and the environment, to use environmental resources in a responsible way, and to educate students and staff about environmental issues. It is the goal of the District to provide for the safest and lowest-risk approach that is effective and economically feasible and protects students, staff, the environment and District property.

The Precautionary Principle, which is the long-term objective of the District's Least Toxic Integrated Pest Management policy, states that when an activity raises threats of harm to the environment or human health, precautionary measures will be considered. The District's objective in adopting this policy is to institutionalize the ongoing practice of , whenever possible, not using pesticides at District operated school sites and implementing a Least Toxic Integrated Pest Management approach.

Pest Management

District buildings and grounds shall be regularly cleaned and repaired in order to prevent infestations, minimize the use of pesticides, and eliminate routine spraying.

The District adopts a Least Toxic Integrated Pest Management (IPM) Policy. Pests and weeds will be controlled to protect the health and safety of students and staff, to maintain a productive learning environment and to maintain the integrity of school buildings and grounds. It is the policy of the Board to focus on long-term pest prevention and give non-chemical methods first consideration when selecting appropriate control techniques. The full range of alternatives, including no action, will be considered first, with chemical controls used only as a last resort, giving preference to chemicals that pose the least possible hazard to people and the environment.

Integrated Pest Management Policy

The elements of the Least Toxic Integrated Pest Management (IPM) Policy are as follows:

- Monitoring to determine pest population levels and identify decisions and practices that could affect pest populations.
- Setting of action levels to determine when vegetation or a pest population at a specific site cause(s) unacceptable economic or medical damage wherein corrective action should be taken.
- Modifying and/or eliminating pest habitats to deter pest populations and minimize pest infestations.
- Considering use of a range of potential treatments for the pest problem, including physical, horticultural, and biological methods of pest control.
- Using chemical controls only as a last resort, and only those chemicals that pose the least possible hazard to people and the environment. The District will not use any Toxicity Category I or Toxicity Category II pesticide product, any pesticide product containing an ingredient known to the state of California to cause cancer, developmental toxicity or reproductive toxicity pursuant to the California Safe Drinking Water and Toxic Enforcement Act of 1986 or any pesticide product containing an ingredient classified by the United States Environmental Protection Agency as a known, possible or probable human carcinogen, reproductive toxin, developmental toxin or endocrine disruptor,except when used in conjunction with an enclosed bait or trap on the Limited Use Products List. Prior authorization must be obtained from the Board of Trustees before any application of pesticides not on the Approved Product List (see AR, pg. 2) to District property. Board authorization will be based on the Superintendent's recommendations incorporating the IPM Committee's advice and review of proposed products. The Superintendent or designee may grant an emergency exemption and authorize application of pesticides pursuant to the guidelines contained in AR 3514 when IPM Committee review is not practicable.

The IPM Coordinator and Annual IPM Plan

The Superintendent shall designate a staff person to coordinate the IPM program. The IPM Coordinator shall be educated in the principles and practices of least toxic IPM and shall be responsible for providing a status report and recommended plan in April of each year to the IPM Committee. The IPM Coordinator shall provide the report and plan, incorporating the IPM Committee's findings, to the Superintendent for submission to the Board. Included in this plan will be administrative regulations for:

- An overall IPM plan listing all proposed products and methods proposed for use.
- Procedures for formal notification to parents, staff and students of any chemical pesticide application, which will include pre- and post-application signage, written notice and a notification registry.
- Record keeping guidelines for any chemical pesticide application and ensuring that records of pesticide use are made available to the public.

- Education and training for District personnel.
- Emergency exemption process.
- Record keeping guidelines for pest monitoring and for non-chemical methods used for pest control.

IPM Committee

The District shall establish an IPM Committee to provide guidance, education and advice regarding IPM policy procedures and practices. The Committee will meet at least annually to review and make recommendations to the Superintendent for submission to the Board regarding all pest management practices. The Committee shall be appointed by the Superintendent and will be comprised of at least the following representatives: Superintendent or designee, the District IPM Coordinator, one IPM professional, one parent of enrolled student(s), and one community and/or environmental organization representative.

Notification

All staff and parents or guardians of students will receive annual written notification addressing, among other things, expected use of pesticide products not on the Approved Use Products List as set forth in the IPM Coordinator's annual turf management and facilities plan.

The District shall provide the opportunity for students, parents, staff and community members to register with the District if they wish to receive notification of planned pesticide applications at a school site. People who register for such notification shall be notified of individual pesticide applications at least 72 hours prior to application. The notice shall include the product name, the active ingredient or ingredients in the product, the intended date of application, target pest and contact with telephone number for more information. The written notice requirement is suspended in emergency situations requiring immediate action of the Superintendent or IPM Coordinator. Warning signs will be posted at the pesticide application site at least 72 hours before the application and remain posted for 72 hours after the application.

These procedures shall be regularly reviewed and updated in order to reflect changed circumstances and to assess progress in achieving District objectives. The Board encourages staff to exchange information with other districts and the County Office of Education about programs, options, and strategies for implementing this policy.

Products on the Approved Use Products List are exempt from the above-stated notification requirements.

Legal References

Education Code: EC 17609 Chapter 5, Part 10.5, Article 4 commencing with Section 17608
Food and Agricultural Code: Article 17 of Chapter 2 of Division 7
Health Safety Code: Chapter 76 Division 103
Board Adopted: August 23, 2001

Board Policy #B-3613

Pesticide Management Practices

Assembly Bill 2260 (Shelley) Stats 2000, Ch. 718, effective January 1, 2001 establishes the Healthy Schools Act of 2000.

The Governing Board of the New Haven Unified School District intends to implement policies and procedures consistent with AB2260. These policies and procedures shall include strategies and methods to:

1. Use the effective, least toxic method of pest control.
2. Maintain pesticide use records at each site for a period of not less than 4 years.
3. Annually provide a list to each school district site of pesticides expected to be used during the forthcoming school year to staff, parents or guardians.
4. Prior to any pesticide application, post warning signs at a the school site.
5. Perform emergency applications.
6. Require that licensed and certified pest control operators include information on any school pesticide application that they perform as part of their otherwise applicable reporting requirements.

These procedures shall be regularly reviewed and updated to achieve the District objectives.

Definitions:

For the purpose of this policy, school site shall mean: any facility used for public daycare, kindergarten, elementary and secondary school purposes. The term includes the buildings, structures, playgrounds, athletic fields, school vehicles, or any other school property visited or used by pupils. Pesticide shall be defined as any economic poison.

Least Toxic Method:

The District designee shall develop an Integrated Pest Management (IPM) program and periodically review the program to ensure that the least toxic, economically feasible methods are used for pest control. This program shall incorporate both chemical and non-chemical procedures.

Notification:

1. The District shall annually provide to all staff, parents or guardians of pupils, enrolled at a school site, a written notification of all pesticide products to be used during the upcoming year. The notice shall identify the ingredients in each pesticide. The notice shall also contain the internet address used to access information on pesticides and pesticide use reduction developed by the Department of Pesticide Regulation pursuant to Section 13184 of the Food and Agriculture Code.

2. The written notification shall provide the opportunity for recipients to receive notification of individual pesticide application at the school facility. The designee shall notify persons who register for such notification of individual pesticide applications at least 72 hours prior to the application. The notice shall include the product name, the active ingredients and the intended date of application.
3. If a pesticide product, not included in the annual notification, is subsequently intended for use at a school site, the District designee shall, at least 72 hours prior to the application, provide written notification of its use.

Notification pursuant to this policy shall be by the least costly manner pursuant to Education Code Section 48980.3, and shall to the extent feasible be included as part of any other written communication provided to individual parents or guardians.

Records Maintenance:

Each school site shall maintain records of pesticide use for a period of 4 years This requirement can be met by retaining a copy of the posting sign for individual applications. These records shall be made available to the public upon request, pursuant to the California Public Records Act. (Legal Reference: Education Code, Section 17611)

Posting Requirements:

The District designee shall post warning signs at each area to be treated. The sign shall include the term "Warning/Pesticide Treated Area", the product name, manufacturers name, the EPA product registration number, date of application, area of application and the target pest. These signs shall be posted 24 hours prior to the application and remain for 72 hours after the application.

Emergency Pesticide Applications:

Pest control measures taken during an emergency, i.e., wherein the school district designee deems that the immediate use of a pesticide is necessary to protect the health and safety of pupils, staff or other persons, or the school site, shall not be subject to the notification requirements herein. However, the District designee shall make every effort to provide the required notification for an application of a pesticide under emergency conditions.

Legal Reference:

California Education Code 17612. Notification of pesticide use 48980.3 Required notification of rights (Chapter 5 Part 10.5, Article 4 of the Education Code commencing with Section 17608; Article 17 of Chapter 2 of Division 7 of the Food and Agricultural Code; Chapter 76 Division 103 of the Health and Safety Code)

Revised	First Reading	Second Reading
	July 17, 2001	August 21, 2001

Series 3000 Bp 3514.3

Business Services

Integrated Pest Management Policy

The Novato Unified School District recognizes that maintenance of a safe, clean and healthful environment for students and staff is essential to learning. It is the goal of the District to provide the safest and lowest risk approach to control pest problems while protecting students, staff, the environment and District properties and assets.

The District adopts a Least-Toxic Integrated Pest Management (IPM) Policy. Pest will be controlled: to protect the health and safety of the students and staff; to maintain a productive learning environment; and, to maintain the integrity of the school buildings and grounds. It is the policy of the District to focus and develop long-term pest prevention methods and give "non-chemical" methods first consideration when selecting appropriate control measures. The full range of alternatives will be considered, giving preference to non-chemical methods, and then chemicals that pose the least hazard to people and the environment.

A Least-Toxic Integrated Pest Management (IPM) Policy contains the following elements:

1. Monitoring to determine pest population levels and identify decisions and practices that could effect pest populations.
2. Setting of injury and action levels to determine when vegetation or a pest population at a specific site cause(s) unacceptable economic or medical damage wherein corrective action should be
3. Modification of pest habitats to deter pest populations and minimize pest infestation.
4. Consideration of a range of potential treatments for the pest problem, including prevention, mechanical, cultural, and biological methods of pest control, using synthetic chemical controls only as a last resort and only those chemicals that pose the least possible hazard to people and the environment.
5. Establish a committee to provide guidance, education and support regarding IPM procedures. Members of the committee will be appointed by the Superintendent and may include the following: Superintendent or designee, Board Member, IPM Coordinator, parent, certificated staff member, classified staff member and one community member at large.
6. Abstain from using any pesticide product containing an ingredient known to the State of California to cause cancer, developmental toxicity, or reproductive toxicity, pursuant to the

California Safe Drinking Water and Toxic Enforcement Act of 1986, or any pesticide product containing an ingredient classified by the United States Environmental Protection Agency as a known human carcinogen, reproductive toxin, developmental toxin or endocrine disrupter.

The Superintendent shall designate a staff person to coordinate the IPM program. The IPM coordinator shall be educated in the principles and practice of least toxic IPM and be responsible to provide:

- Oversight for the successful implementation of the program consistent with this policy and coordinate all District efforts to adopt IPM.
- Overall program management and provide proposed procedures and products for use in managing pest populations.
- Formal notification to parents, staff and students of any chemical pesticide application including pre-and-post signage.
- Establish and maintain a registry of parents, staff and students that have indicated they desire notification 72 hours prior to pesticide applications.
- Record-keeping guidelines for any chemical pesticide application.
- Education and training for IPM personnel.
- A list of approved procedures and products.

Legal References:

EDUCATION CODE

17608 - 17613 Healthy Schools Act of 2000

48980.3 Healthy Schools Act of 2000

FOOD AND AGRICULTURAL CODE

13180 Healthy Schools Act of 2000

San Diego Unified School District
IPM Policy

(This policy was adopted on October 22, 1991, by the San Diego Unified School District.)

Structural and landscape pests can pose a significant problem to people and the environment. Hazardous pest control chemicals can also pose a significant problem to people and the environment. It is therefore the policy of the San Diego Unified School district to incorporate Integrated Pest Management (IPM) procedures for the control of structural and landscape pests. IPM means that pest problems will be alleviated with the least possible hazard to people, property, and the environment by using IPM methods that are safe, effective and economically feasible. Pesticides will be carefully evaluated before use and will only be used after non-hazardous and other safer methods have been considered.

Integrated Pest Management will include the following components:

1. Educate staff, students and the public about school pest problems and the Integrated Pest Management policies.
2. Develop plant inventory and pest problem survey procedures.
3. Identify pests that are considered public health problems and methods to prevent them in the least hazardous way from becoming a health problem.
4. Identify and evaluate cultural/environmental conditions on the grounds that encourage pest problems. Make recommendations for remedial action.
5. Monitor population levels of pests to determine treatment procedures.
6. Review all available options for acceptability and/or feasibility before the use of a chemical pesticide; cost of staffing considerations alone will not be the sole justification for use of chemical control agents. Records of IPM strategies considered prior to chemical treatment will be maintained.
7. Ensure that pesticide applicators whether in-house or contracted are educated and trained in the use of current pesticides approved for use by the SDUSD and that they follow label precautions and application regulations. Contracted companies are to be in compliance with the San Diego Unified School District's Integrated Pest Management policy.
8. Establish and maintain pesticide use reporting and recordkeeping procedures.
9. Establish system to evaluate and measure control success.
10. Make information accessible to the public and employees regarding pesticides used and area treated.
11. Eliminate fire potential (e.g. tall, dry grass, dead trees) in the safest and most timely manner using available resources.

APPENDIX F

IPM-Related Curricula and Resources for the Classroom

BugPlay

For grades K through 3. Hands-on experiences with harmless insects help students develop an appreciation for these amazing creatures. Lessons, with accompanying music cassette, include the use of poems, songs, and drawings. Available from: Addison Wesley Publishing Co., (800) 552-2259

Learning about Pesticides at School:

Project Ideas for High School or Middle School Classrooms or Student Environmental Clubs. September, 199; 22 pp. plus 8 page glossary

Teaching/learning activities designed for middle school and high school level students. It includes a variety of activities that can be combined into one comprehensive school pesticide use reduction project. This is an ideal project for interdisciplinary classes or environmental clubs. The project also involves activities appropriate in traditional health, chemistry, biology, ecology, math, speech, and social studies classrooms. Better yet, it involves students in a "real-world" project that will make a difference in their own lives.

Available from: Northwest Coalition for Alternatives to Pesticides (NCAP), P.O. Box 1393, Eugene, OR 97440 or call (541) 344-5044.

Legacy of a Pest

A science, technology, and social studies curriculum guide for understanding and dealing with pest problems. There are over 50 teacher-tested activities dealing with the gypsy moth problem, its life cycle, IPM control strategies, chemical control strategies, and more. 243 pp.

Available from: Legacy of a Pest, 607 E. Peabody Dr., Champaign, IL 61820 or call (217) 333-6880.

Living With Insects in the Big City: Urban Insect Ecology and Safe Pest Management

A curriculum for grades K-3. It contains hands-on activities, teaches science framework concepts and applies biological concepts to our urban world. Also included are graphic aids.

Available from: Citizens for a Better Environment (CBE), 500 Howard St., Ste. 506, San Francisco, CA 94105 or call (415) 243-8373.

Teaching Ideas: Pesticide Awareness and the Concept of Integrated Pest Management

Curriculum is suitable for use in middle, junior, or senior high school biology, ecology, or social studies courses. Included is "How to Map Pesticide Use in your School (and Community)," and four lesson plans on pesticides and Integrated Pest Management concepts.

Available from: Northwest Coalition for Alternatives to Pesticides (NCAP), P.O. Box 1393, Eugene, OR 97440 or call (541) 344-5044.

The Growing Classroom

For grades 2 through 6. Students use indoor and outdoor gardens for the study of science and nutrition through experimentation, investigation, and data collection and analysis.

Available from: Addison Wesley Publishing Co. at (800) 552-2259.

The Young Entomologists' Society (Y.E.S.)

An international society of young and amateur insect enthusiasts. It operates on a membership basis and publishes several newsletters, sells books, educational toys, and clothing. This organization encourages active involvement of its young members and communication with each other, primarily through the mail. A catalog of their publications is available.

For more information, write to Y.E.S. Inc., 1915 Peggy Place, Lansing, MI 48910-2553 or call (517) 887-0499.

APPENDIX G

Pesticide Information Resources

Product manufacturers can provide information on hazards, efficacy, and safe disposal of pesticides. They are required to provide the public with a sample label and an MSDS (material safety data sheet) on request.

The Department of Pesticide Regulation (DPR) is responsible for regulating pesticides in California. This includes product evaluation and registration, environmental monitoring, residue testing of fresh produce, and local use enforcement through the county agricultural commissioners. DPR's home page is http://www.cdpr.ca.gov/.

DPR's School IPM Web site contains school-specific information regarding pest management, pesticide safety and environmental and health impacts of pesticide use. It can be found at http://www.schoolipm.info/

DPR Pesticide Databases—Look up pesticide products by active ingredient, product name, and other criteria, and then select "full report" for a brief summary of toxicity information. The databases contain only California-registered products. Follow the "Product and Use Data" link at http://www.cdpr.ca.gov/

For more information, call (916) 324-4100, visit http://www.cdpr.ca.gov/ or write to DPR at 1001 I Street, P.O. Box 4015, Sacramento, CA 95812-4015.

Cooperative Extension personnel (look in the government section of the phone book under Cooperative Extension or visit http://ucanr.org/ce.cfm) can provide information on the hazards and efficacy of pesticides. They can provide up-to-date information about pesticides registered for a particular pest. The Cooperative Extension office also provides services for insect identification.

Each county in California has a County Office of Agriculture that is available to give assistance. Check the government section of the phone book for the closest office.

The National Pesticide Information Center (NPIC) operates a toll-free hotline, staffed by toxicologists, to provide the general public as well as the medical, veterinary, and other professional communities with information on pesticide poisonings, correct use of pesticides, referrals for laboratory analyses and investigation of pesticide incidents, emergency treatment information and pesticide clean-up and disposal procedures

For more information, call NPIC at (800) 858-7378 (hotline), visit http://npic.orst.edu/ or write to NPIC, Oregon State University, 333 Weniger, Corvallis, OR 97331-6502

US EPA Office of Pesticide Programs—This site includes consumer alerts, health and environmental effects of pesticides, pesticide fact sheets, educational materials and information on pesticide registrations.

For more information, visit http://www.epa.gov/pesticides/ or write to US Environmental Protection Agency, Office of Pesticide Programs, Ariel Rios Building, 1200 Pennsylvania Ave. NW, Washington, D.C. 20460

Compendium of Pesticide Common Names—Find active ingredients associated with pesticide common names. This electronic compendium is intended to provide details of the status of all pesticide common names, together with their systematic chemical names, molecular formulae and Chemical Abstracts Registry Numbers.
http://www.hclrss.demon.co.uk/

An Introduction to Insecticides—A summary of common insecticides, written by Professor Emeritus George Ware of University of Arizona. It is somewhat technical.
http://ipmworld.umn.edu/chapters/ware.htm

See also Ware, G.W. (2000). The Pesticide Book, 5th Ed. Thomson Publications, Fresno, California. 415 pp.

EXTOXNET—Look up many (not all) pesticide active ingredients, and check toxicology information. "Pesticide Information Profiles" can be searched or browsed. This Web site is produced by a consortium of universities.
http://www.ace.orst.edu/info/extoxnet/ghindex.html

Joint UNEP, WHO GEENET Chemicals Site—This site contains sources of information on pesticides and other chemicals from the United Nations Environmental Program, World Health Organization, and other international bodies.
http://irptc.unep.ch/ or write to: UNEP Chemicals 11-13, chemin des AnÈmones, 1219 Ch,telaine, Geneva, Switzerland.

APPENDIX H

IPM for Schools Recommended Reading

School IPM Manuals

Daar, S., Drlik, T., Olkowski, H., and Olkowski, W. 1997. IPM for Schools: a How-To Manual. Bio-Integral Resource Center, Berkeley, CA. 215 pp.

The California School IPM Guidebook was based in part on this publication. It was published in association with U.S. EPA region IX and can be found online at http://www.epa.gov/region09/toxic/pest/school/index.html

Martz, E., Ed. 2001. IPM for Pennsylvania Schools: a How-To Manual. Pennsylvania Integrated Pest Management Program 112 pp.

This manual was based in part on the IPM for Schools: A How-to Manual, published by U.S. EPA region IX in association with the Bio-Integral Resource Center. It can be accessed at http://paipm.cas.psu.edu/schoolmn/contents.htm.

Regents of the University of Wisconsin System. 2000. Wisconsin's School Integrated Pest Management Manual.

This online School IPM Manual be viewed at http://ipcm.wisc.edu/programs/school/table.htm

Stauffer, S., Ferrentino, R., Koplinka-Loehr, C., and Sharpe, K. 1998. IPM Workbook for New York State Schools. Cornell Cooperative Extension. IPM Publication Number 605. 155pp.

This is an excellent, easy-to-read school IPM manual. It can be found online at http://www.nysipm.cornell.edu/publications/ under "The School IPM Workbook" link.

General IPM

Dreistadt, S.H., J.K. Clark, and M.L. Flint. 1994. Pests of Landscape Trees and Shrubs: an integrated pest management guide. University of California Statewide Integrated Pest Management Project, Division of Agriculture and Natural Resources (Publication 3359), Davis, CA. 327 pp.

Excellent guide for managing problems on a wide variety of plants; each pest is illustrated with a color plate.

Ebeling, W. 1975. Urban Entomology. University of California, Division of Agricultural Sciences, Los Angeles. 695 pp.

A classic text on the biology and management of urban pests, including rats and mice. Excellent drawings and photographs and a readable text make it outstanding. Dr. Ebeling is the U.S. expert on the use of silica gel, boric acid, and other least-toxic pesticides for insect control in urban and suburban environments. Only available online at http://entmuseum9.ucr.edu/ent133/ebeling/ebeling.html

Flint M.L. 1998. Pests of the Garden and Small Farm: a grower's guide to using less pesticide, 2nd Edition. University of California Statewide Integrated Pest Management Project, Division of Agriculture and Natural Resources (Publication 3332), Davis, CA. 286 pp.

Summarizes IPM approaches to more than a hundred pest insects, weeds, and plant diseases found in the U.S. and Canada. Beautifully illustrated with color plates.

Hygnstrom, S.E., R.M. Timm, and G.E. Larson, eds. 1995. Prevention and Control of Wildlife Damage. University of Nebraska, Institute of Agriculture and Natural Resources, Lincoln. 250 pp.

This loose-leaf book is the most comprehensive source of information available on managing wildlife pest problems. The groups covered include rodents, bats, deer, birds, reptiles, and others.

Leslie, A.R. 1994. Handbook of Integrated Pest Management for Turf and Ornamentals. Lewis Publishers, Boca Raton, FL. 660 pp.

The EPA assisted in the development of this book with the stated purpose of reducing pesticide pollu-

tion. It is intended for professionals who deal with urban landscaping and turf management of all kinds.

Madison, J.H. 1971. Practical Turfgrass Management. PWS Publishers, Boston. 466 pp.

This is the best lawn management text yet written.

Mallis, A. 1997. Handbook of Pest Control 8th ed. CIE Publications, Cleveland, OH. 1,400 pp.

A classic work on urban pests. Excellent reference book.

Marer, P.J. 2000. The Safe and Effective Use of Pesticides, 2nd Ed. University of California Statewide Integrated Pest Management Project, Division of Agriculture and Natural Resources (Publication 3324), Davis. 352 pp.

This book provides updated and detailed information for selecting, using, handling, storing, and disposing of pesticides. It is the study guide for all categories of DPR's Qualified Pesticide Applicator License and Qualified Pesticide Applicator Certificate exams.

Moore, H.B. 1995. An Introduction to Wood Destroying Insects: their identification, biology, prevention and control. Pest Control Magazine, Cleveland, OH. 120 pp.

Good descriptions of and control information for termites, wood-boring beetles, wood wasps, carpenter bees, and carpenter ants.

Olkowski, W., S. Daar, and H. Olkowski. 1991. Common-Sense Pest Control. - Least-toxic solutions for your home, garden, pets and community. Taunton Press, Newtown, CT. 715 pp.

An excellent, comprehensive resource book on IPM. Illustrated with photos, drawings, tables, and charts.

Schultz, W 1989. The Chemical-Free Lawn. Rodale Press, Emmaus, PA. 194 pp.

An excellent primer on lawn care without the use of synthetic chemical products.

Ware, G.W 1999. The Pesticide Book. 5th ed. Thomson Publications, Fresno, CA. 418 pp.

This valuable reference is arranged by type of pesticide: insecticide, rodenticide, avicide, herbicide, etc. It includes discussions on modes of action, pesticide resistance, toxicity and hazards, and safe handling and storage.

APPENDIX I

Sample IPM Contracts

Sample IPM Contract Language for Landscape Contracts and Structural Contracts

The following sections include sample language and components of a contract specific to an IPM service contract. This model provides program descriptions and statements of work. This is not intended to be a ready-to-go contract since certain sections that may be required for use in individual districts is not included, such as General Terms and Conditions, Disputes, etc. Contact the school district contracts manager for assistance.

Landscape IPM: Contract Components and Sample Language

adapted from the State of Maryland's School IPM Contract Manual

Background

The basis of the [Name School] school district IPM services is the use of IPM strategies that emphasize pest prevention and the safe and effective management of pest problems. This involves the regular monitoring for the presence of pests in the landscape, in turf and surrounding grounds of school buildings and, when necessary, implementation appropriate control measures. The goal of the IPM program is to provide effective, long-term pest control, while minimizing the use of pesticides. The Contractor must exhibit awareness and sensitivity to the fact that the school environment cannot be compromised through deliberate or inadvertent contamination by pesticides.

Scheduled, routine pesticide treatments in any area of the school are prohibited. Pesticides should be applied only when nonchemical methods have proven ineffective or are impractical, and only in areas of known infestation. It is essential to the success of the IPM program that the Contractor provides proactive services that identify landscape design deficiencies, plant maintenance practices, and plant choices that contribute to pest problems.

All IPM services and activities shall be planned and performed with the needs of the school children and staff as the foremost priority, working with school site staff to coordinate pest management activities to avoid disruption of school activities.

Description of Service

The Contractor shall furnish all labor and materials for the development and implementation of a comprehensive IPM program in designated schools and facilities. The Contractor shall demonstrate an understanding of the concept of IPM. The implementation of management practices in an IPM program is not based on the routine application of pesticides, but on monitoring and inspecting for pests, modifying landscapes and plant selection, and changing landscape and plant maintenance practices that can contribute to pest problems. Pest control is achieved in an IPM program by emphasizing pest prevention and making informed and accurate decisions as to when control measures are needed and the type of control measures to be used.

At a minimum, the IPM program shall consist of the development and implementation of routine pest management services; routine and special meetings among pest management personnel and school staff; routine and specially scheduled training; and written reports describing program status and recommendations for the corrective actions that need to be implemented by the school, the Contractor, or the school board.

IPM Coordinator and Liaison

To provide the degree of oversight and consistency of services necessary for a successful IPM program, the school districts shall designate an IPM Coordinator for the school district and an IPM liaison for each individual school. The IPM Coordinator is responsible for the notification, posting and recordkeeping requirements of the Healthy Schools Act {See section 1.4 of the guidebook for the requirements of the Healthy Schools Act}. These people should have the interest and capability to address all pest management issues, regardless of the pest involved or the area affected. The IPM Coordinator should participate in all decisions that may directly or indirectly affect pest management. A list of personnel designated as school liaisons should be provided to the Contractor by the school district. The Contractor's pest management technician should meet with the school liaison, upon initiation of the contract, and prior to performing pest management services. The Contractor and school liaison will:

1. Identify and discuss specific problem areas in the landscape and turf areas;
2. Facilitate access to all management areas on school property;
3. Identify and discuss landscape features or maintenance practices that might contribute to pest infestations;
4. Discuss effectiveness of previous control efforts; and
5. Notify pest management personnel of any new restrictions or special safety precautions.

Routine Services

Routine IPM Services shall include the control of all landscape and turf pests such as, but not limited to, defoliating insects, sucking insects and mites, wood-boring insects, leaf mining insects, gall-forming insects and mites, root-feeding insects, diseases of ornamental landscape plants and turf grass, weeds, and vertebrate pests including gophers, ground squirrels, voles, moles, birds, deer and other vertebrate pests. Preventive recommendations for control of these pests are included as Routine IPM Services.

Additional Services

The school district reserves the right to negotiate with the Contractor for the purchase of related pest control services not specifically covered, such as pruning, tree removal, and other plant maintenance practices, and to add or delete grounds or fields to or from the Contract.

Special Service Request and Emergency Services

Routine IPM services shall consist of performing all components of an IPM program, as described in the Contractor's Pest Management Plan and Service Schedule (see Pest Management Plan and Service Schedule below) for each school management area during the period of this contract.

Requests for corrective action, special services, or emergency service shall be placed with the IPM Coordinator. The Contractor shall respond to a request for emergency services on the day of the request. In addition, the Contractor shall respond to special service requests within one (1) working day after receipt of request. If the special service or emergency service request entails the application of pesticides, applications will take place in the minimum time allowable by law. All emergency and special services should be recorded in the school IPM logbook. In the event that such services cannot be completed within the required time frames, the Contractor shall immediately notify the IPM Coordinator and indicate an anticipated completion date. The Contractor shall describe, in the proposal, his/her capability to meet this requirement (e.g., radio-dispatched service, names of office personnel handling the account, availability of technical and on-site personnel assigned to this program).

Pest Management Plan and Service Schedule

The Contractor shall survey all management areas covered under this contract and develop a written Pest Management Plan. This plan shall provide detailed information on areas of pest infestation; landscape design, plant selection deficiencies, and plant maintenance practices that contribute to pest infestation; and recommendations for correcting those conditions.

This plan should include a detailed description of the monitoring program that will be used to identify pest infestations in landscape and turf areas. It may include the use of traps, visual inspections, degree-day accumulations and other environmental indicators, and staff interviews. Other appropriate IPM activities, including decision making, intervention tactics and strategies, and evaluation methodologies should be included. A school system-approved pesticide list with labels and Material Safety Data Sheets (MSDS), if available, should be included in the management plan. The Contractor also shall submit a written Service Schedule to the IPM Coordinator and other school personnel for approval. This schedule will be structured so that the entire school grounds, landscapes, and turf areas are surveyed routinely.

The frequency of service visits for each management unit should be specified. This document should be included with the IPM service records of each school and revised as necessary.

The Pest Management Plan and Service Schedule must be approved by the school district before implementation of the program. This specifically includes approval for any proposed pesticide usage. Any subsequent changes to the Plan and Schedule and/or additions to the approved pesticide list must be requested in writing and receive the concurrence of the school district.

Structural and Procedural Recommendations

Landscape maintenance practices that may contribute to structural pest infestations shall be reported, in writing, to the building liaison and the IPM Coordinator by the Contractor at the completion of each inspection.

Recordkeeping

The Contractor shall provide and maintain a complete and accurate pest management logbook. The logbook shall permit efficient evaluation and management of the program, accurate information retrieval, and adhere to recordkeeping required by California law. The logbook shall be kept in a designated location at the facility and a copy sent to the IPM Coordinator following each service visit. Clear and concise records shall reflect the common names of pests monitored at the school as well as turf and landscaping maintenance deficiencies, problem plants, nonpesticidal and pesticidal control measures applied, immediate and long-term recommendations regarding pest management, communications with students and staff, MSDS, and labels for all products that may be used at the facility. A section of the logbook shall be allocated for school personnel to report pest sightings and other information that shall be reviewed by that Contractor during regular service visits. The Contractor shall provide, in the proposal, an example of the logbook format with a detailed explanation of how it will be used, the structure of the book, and information that has to be recorded in the logbook.

Contractor Licensing

Each Contractor submitting a proposal for consideration by the school district shall have and maintain, during the life of the contract, a California Pesticide Business License issued by DPR or the Structural Pest Control Board.

A copy of the current valid license shall be submitted with the Contractor's proposal and no consideration will be given to proposals that lack evidence of licensing. Failure to maintain the Pesticide Business License with all necessary pest control categories shall be sufficient grounds for immediate termination of the contract. It shall be the Contractor's responsibility to immediately notify the IPM Coordinator of any change in status.

Personnel

The Contractor shall provide, under this contract, only qualified pest management personnel with adequate and verifiable experience in the conduct of IPM programs. All on-site personnel must understand current pest management practices and be able to make decisions and field diagnoses regarding the use of IPM practices and techniques. The proposal shall present a plan or method for assuring continuity of pest management personnel assigned to this contract, and knowledge and sensitivity to the needs of the schools. The Contractor should understand that quality assurance and daily pest management services are two activities that are separate and distinct from one another, and require sufficient time and manpower.

The Contractor shall designate a Program Technical Supervisor (PTS), who shall have primary responsibility for the conduct of this pest management contract, ensure that all required reports are submitted to the IPM Coordinator on time, and be available for routine and emergency consultation. The following minimum requirements regarding this individual's experience and training shall be provided in the proposal:

1. Resume, including current home address.
2. Current certification or licensure in California as a Pest Control Applicator. Certification as a Pest Control Advisor also is acceptable.

The PTS shall provide on-site supervision to assure safety, carry out coordination and continuity of program services, and fulfill special requests from the IPM Coordinator. The responsibilities of the on-site supervisor will be carried out by the PTS, not the pest management technician. A pest management technician shall provide on-site pest management services.

Manner and Time to Conduct Services

Routine services should be performed during the late afternoon hours, Monday through Friday, excluding holidays, except when school is not in session or as specifically approved by the IPM Coordinator. Pesticides shall not be applied while foods are being prepared, served, or put away, or when the school building is open for business.

The Contractor shall observe all safety precautions throughout the performance of this contract. Certain areas within some facilities may require special instructions for persons entering the area. Any restrictions associated with special areas will be explained to the Contractor and the IPM Coordinator by the school building liaison. These restrictions shall be adhered to and incorporated into the Contractor's Pest Management Plan and Service Schedule for the school building.

All contracted personnel shall wear an identification card in a clearly visible manner during the performance of their duties. Vehicles used by the Contractor or the contractor's personnel shall be identified. The Contractor must park in designated areas in close proximity to each school building. At a minimum, the Contractor shall provide his/her personnel with clean uniforms to be worn while performing their duties. Additional personal protective equipment required for the safe performance of work shall be determined and provided by the Contractor in compliance with California law

Nonchemical Alternatives

Nonchemical pest management alternatives include biological, physical, cultural and mechanical methods. Nonchemical management of weeds may include the repair of cracks and crevices in sidewalks, playgrounds, and parking lots to reduce germinating seeds. Weeds in planted beds may be managed through the use of mulching or mechanical removal such as hoeing or hand picking. In some cases, biological control agents may be released to help control weeds. Nonchemical control of weeds in lawns and playing fields may include alterations of turfgrass variety, or changes in mowing heights or in fertilization and irrigation regimes. Nonchemical management of insect and disease pests of landscape plants may include the removal of pest-prone plants and replacement with pest resistant varieties, the addition of plants to the landscape that encourage the activities of beneficial insects or discourage the activities of pests, the physical removal of pests by pruning or hand picking, the use of barriers to prevent colonization of plants, the use of various traps to capture pests or disrupt activities such as mating, the release of biological control agents, and the alteration of practices such as fertilization, irrigation, mulching, and pruning to discourage pest activity.

Pesticide Alternatives. Pesticide applications shall be made only to areas of known pest infestation or activity, and where nonchemical control measures, such as plant selection, habitat modification, physical, mechanical, and biological control were not successful or are not feasible.

Application of pesticides shall not occur until a full inspection has been completed. If chemicals are needed, least-hazardous pesticides and formulations, such as boric acid, silica gels, and diatomaceous earth should be considered whenever possible.

Pesticide applications that may impact the operations or occupants of a school building shall be permitted only during hours when the school building is closed and after all notification procedures have been met. See Part One in this guidebook for a summary of regulations pertaining to notification. A contingency plan for performing pesticide applications on school grounds should be part of the Pest Management Plan and Service Schedule. This should include a list of pests, pesticide products, formulations, application methods, timing of application, and other relevant information that may be needed in specific situations and landscape areas.

Thresholds for pests of landscape plants are generally lacking. However, several studies indicate that insect and mite pests cause noticeable aesthetic injury to plants when approximately 10 percent of the plant is affected. Treatments should be considered when 10 percent of a plant's foliage is removed or discolored, or if the pest has the potential to kill the plant, as is the case with some boring and scale insects. Controls should be initiated against weeds in sidewalks, play areas, parking areas, and driveways when they pose a threat to safe pedestrian traffic or create serious structural damage to these surfaces. Insect, disease, and weed pests of turfgrass in playing fields should be controlled when the associated loss of turfgrass poses a threat of injury to children engaged in sports activities. Insect, disease, and weed pests of school lawns should be controlled only when the damage caused by these pests is intolerable.

The Contractor shall minimize the use of and potential exposure to pesticides wherever possible.

For example:

1. Use nonchemical control methods and materials.

2. Use spot treatments of pesticides. Treat only heavily infested plants.

3. Integrate control methods (i.e., plant selection, timing of watering, mechanical weed control, etc.).

4. Use reduced-risk pesticide application techniques, such as soil injections, rather than foliar applications, when possible.

5. Routine preventive pesticidal spray treatments are prohibited. Cover or barrier treatment of grounds with a pesticide must be specifically requested by the Contractor and approved by the IPM Coordinator, prior to performing the treatment. Preventive pesticide treatments are acceptable only on a case-by-case basis. The Contractor must provide detailed plans; list the rationale for the treatment, and the methods of application if preventive treatment is warranted for a specific school building or landscape area. Preventive treatments are subject to review by the IPM Coordinator and can be eliminated at any time.

Reporting

The Contractor's Program Technical Supervisor shall, at a minimum, provide annual written reports to the school district and attend regular meetings with the IPM Coordinator, school administration, school liaisons, and other concerned individuals. These reports and meetings will address all pest management activities provided by the Contractor for each facility's grounds and evaluation of the IPM program's progress. These reports should identify landscape conditions or personnel practices that require correction by the school district in order to promote the program' s overall effectiveness. In addition, the Contractor shall provide monthly service reports to the IPM Coordinator within 15 days following the end of each month. The service reports shall include, but not be limited to, the following:

1. Landscape and turf areas serviced.

2. Man-hours for each facility's grounds for Routine Services.

3. Location, man-hours, and work description of Special, Emergency, and Additional Services.

4. Results of monitoring and inspections, including accepted common names of pests, numbers of each pest, and the location on each facility's grounds.

5. Written evaluation of turf conditions, landscape problems, specific plant infestation, and immediate and long-term program goals for either resolving pest problems or improving the IPM program for each facility's grounds.

6. Identification and listing of pesticides used by common/generic name (no codes), concentration and quantity of finished spray used, and other pest management techniques used for each school building and management area.

Evaluation

Monthly service reports during the growing season and annual reports will be used by the IPM Coordinator and the Contractor to develop a tangible means for evaluating the overall IPM effort on the facility's grounds. The Contractor's Program Technical Supervisor shall meet as needed with the IPM Coordinator to discuss the status of the pest management program and review program activities and reports, or resolve ongoing or special problems. If the school district hires an outside evaluator, the contractor may be required to meet with this person or provide information.

Training

The Contractor shall include, in the bid proposal, a detailed description of the in-service training programs provided to their personnel, including pertinent documentation and records. In addition, the Contractor should be able to provide training or develop a plan to use outside expertise to provide training on all aspects of IPM program design and implementation to a wide array of school-associated personnel, including school administrators, maintenance and housekeeping staff, the IPM Coordinator and school liaisons, and community members.

Notification

The Contractor shall provide the IPM Coordinator and school liaisons with a list of pesticides that may be used on school grounds before the school year begins. Product labels and Material Safety Data Sheets for all pesticides shall be provided to the IPM Coordinator and made available in the school IPM program logbook for review by school liaisons, parents, and other interested parties.

The Contractor shall notify the IPM Coordinator and school building liaisons in advance of all pesticide applications to ensure that all provisions of the State and school district's advance notification policies are met. Although each school district is ultimately responsible for student notification of pesticide use and for sending notification home with students, the Contractor will be responsible for satisfying all legal requirements for posting. The Contractor will notify the IPM Coordinator upon completion of pesticide applications made to school grounds.

Inspections

Throughout the duration of this contract, school facilities (or grounds) will be inspected periodically by school district personnel to determine the effectiveness of the IPM program and Contractor compliance with the contract. Inspection results will be documented in writing and submitted to the Contractor. The Contractor shall initiate actions promptly to correct all deficiencies found.

It shall be the Contractor's responsibility to furnish an adequate supply of materials necessary for school personnel to inspect the interior of all rodent bait stations. These materials may include Allen wrenches to loosen and retighten fasteners, keys to open locks, or replacement self-locking plastic ties. Implements to cut plastic ties are not included under this provision.

Purchase of Ancillary Services/Equipment

The Contractor may need to purchase additional equipment or provide additional services to ensure that the IPM program is fully implemented. The school district has the right to negotiate the purchase of ancillary equipment and services with the Contractor and adjust the contract accordingly.

Structural IPM: Contract Components and Sample Language

adapted from the State of Maryland's School IPM Contract Manual

Background

The basis of the [Name School] school district IPM services is the use of IPM strategies that emphasize pest prevention and the safe and effective management of pest problems. This involves the regular monitoring for the presence of pests inside and around the structures of school buildings and, when necessary, implementation of appropriate control measures. The goal of the IPM program is to provide effective, long-term pest control, while minimizing the use of pesticides. The Contractor must exhibit awareness and sensitivity to the fact that the school environment cannot be compromised through deliberate or inadvertent contamination by pesticides. Scheduled, routine pesticide treatments in and around any area of the school are prohibited. Pesticides should be applied only when nonchemical methods have proven ineffective or are impractical, and only in areas of known infestation.

It is essential to the success of the IPM program that the Contractor provides proactive services that identify housekeeping and structural design deficiencies that contribute to pest problems. All IPM services and activities shall be planned and performed with the needs of the schoolchildren and staff as the foremost priority, working with school site staff to coordinate pest management activities to avoid disruption of school activities.

Description of Service

The Contractor shall furnish all labor and materials for the development and implementation of a comprehensive IPM program in designated schools and facilities. The Contractor shall demonstrate an understanding of the concept of the IPM method of pest control. The implementation of management practices in an IPM program is not based on the routine application of pesticides, but on monitoring and inspecting for pests, modifying structures, improving sanitation, and changing personnel practices that can contribute to pest problems. Pest control is achieved in an IPM program by emphasizing pest prevention and making informed, accurate decisions as to when control measures are needed and the type of control measures to be used.

The Contractor also shall provide evidence, in the proposal, of an understanding of the principles and practices governing sanitation in food service areas, in addition to other areas of the school, and the impact of pests and pest management methods on the ongoing activities of a food service facility. At a minimum, the IPM program shall consist of the development and implementation of regularly scheduled pest management services; routine and special meetings among pest management personnel and school staff; routine and specially scheduled training; and written reports describing program status and recommendations for the corrective actions that need to be implemented by the school, the Contractor, or the school board.

IPM Coordinator and School Liaison

To provide the degree of oversight and consistency of services necessary for a successful IPM program, the school districts shall designate an IPM Contact Person (IPM Coordinator) for the school district and an IPM liaison for each individual school. The IPM Coordinator is responsible for the notification, posting and recordkeeping requirements of the Healthy Schools Act {See section 1.4 of the guidebook for the requirements of the Healthy Schools Act}. These people should have the interest and capability to address all pest management issues, regardless of the pest involved or the area affected. The IPM Coordinator should participate in all decisions that may directly or indirectly affect pest management. A list of personnel designated as school liaisons should be provided to the Contractor by the school district. The Contractor's pest management technician should meet with the school liaison, upon initiation of the contract, and prior to performing pest management services. The Contractor and school liaison will:

1. Identify and discuss specific problem areas in the facility;

2. Facilitate access to all management areas on school property;

3. Identify and discuss building features or personnel practices that might contribute to pest infestations;

4. Discuss effectiveness of previous control efforts; and

5. Notify pest management personnel of any new restrictions or special safety precautions.

Routine Services

Routine IPM Services shall include the control of all pests in and around school buildings such as, but not limited to, cockroaches, ants, fleas, stinging insects and nests accessible from the ground or from windows, rats and mice, flies, fruit flies, silverfish, stored products pests; and incidental invaders, such as crickets, earwigs, midges, millipedes, centipedes, ground beetles, clover mites, birds, bats, and squirrels.

Preventive recommendations for control of these and other pests, including wood-destroying insects like termites, carpenter ants, and wood-boring beetles also are included as Routine IPM Services. Treatment for the wood-destroying insects mentioned above is considered an Additional Service (see the section on Additional, Special, and Emergency Services below).

Additional Services

The school district reserves the right to negotiate with the Contractor for the purchase of related pest control services not specifically covered, such as subterranean and structural control of termites and other wood-boring insects, bird control, and to add or delete buildings or parts of buildings to or from the contract.

Special Service Request and Emergency Services

Routine IPM services shall consist of performing all components of an IPM program, as described in the Contractor's Pest Management Plan and Service Schedule (see the section on Pest Management Plan and Service Schedule below) for each school management area during the period of this contract. Requests for corrective action, special services, or emergency service shall be placed with the IPM Coordinator. The Contractor shall respond to a request for emergency services on the day of the request. In addition, the Contractor shall respond to special service requests within one (1) working day after receipt of request. If the special service or emergency service request entails the application of pesticides, applications will take place in the minimum time allowable by law. All emergency and special services should be recorded in the school IPM logbook. In the event that such services cannot be completed within the required time frames, the Contractor shall immediately notify the IPM Coordinator and indicate an anticipated completion date. The Contractor shall describe, in the proposal, his/her capability to meet this requirement (e.g., radio-dispatched service, names of office personnel handling the account, availability of technical and on-site personnel assigned to this program).

Pest Management Plan and Service Schedule

The Contractor shall survey all management areas covered under this contract and develop a written Pest Management Plan. This plan shall provide detailed information on areas of pest infestation; structural, housekeeping, maintenance, and design deficiencies that contribute to pest infestation; and recommendations for correcting those conditions. This plan should include a detailed description of the monitoring program that will be used to identify infested areas. It may include the use of traps, visual inspections, and staff interviews. Other appropriate IPM activities, including decision making, intervention tactics and strategies, and evaluation methodologies should be included.

A school system-approved pesticide list with labels and Material Safety Data Sheets should be included in the management plan. The Contractor also shall submit a written Service Schedule to the IPM Coordinator and other school personnel for approval. This schedule will be structured so that the entire school building, trash room, exterior, and support areas of the building are monitored routinely. The frequency of service visits for each management unit should be specified. This document should be included with the IPM service records of each school and revised as necessary.

The Pest Management Plan and Service Schedule must be approved by the school district before implementation of the program. This specifically includes approval for any proposed pesticide usage. Any subsequent changes to the Plan and Schedule and/or additions to the approved pesticide list must be requested in writing and receive the concurrence of the school district.

Structural and Procedural Recommendations

Structural deficiencies and poor housekeeping practices that may contribute to structural pest infestations shall be reported, in writing, to the building liaison and the IPM Coordinator by the Contractor at the completion of each inspection.

Recordkeeping

The Contractor shall provide and maintain a complete and accurate pest management logbook. The logbook shall permit efficient evaluation and management of the program, accurate information retrieval, and adhere to recordkeeping required by law. Each facility shall have its own logbook that will be updated during each service by the pest management technician. The logbook shall be kept in a designated location at the facility and a copy sent to the IPM Coordinator following each service visit. Clear and concise records shall reflect the common names of pests monitored at the school, as well as structural, maintenance, and housekeeping deficiencies, nonpesticidal and pesticidal control measures applied, immediate and long-term recommendations regarding pest management, communications with students and staff, Material Safety Data Sheets (MSDS), and labels for all products that may be applied at the facility. A section of the logbook shall be allocated for facility personnel to report pest sightings and other information that shall be reviewed by the Contractor during regular service visits. The Contractor shall provide, in the proposal, an example of the logbook format with a detailed explanation of how it will be used, the structure of the book, and information that has to be recorded in the logbook.

Contractor Licensing

Each Contractor submitting a proposal for consideration by the school district shall have and maintain, during the life of the contract, a California *Pesticide Business License.* A copy of the current valid license shall be submitted with the Contractor's proposal and no consideration will be given to proposals that lack evidence of licensing. Failure to maintain the *Pesticide Business License* shall be sufficient grounds for immediate termination of the contract. It shall be the Contractor's responsibility to immediately notify the IPM Coordinator of any change in status.

Personnel

The Contractor shall provide, under this contract, only qualified pest management personnel with adequate and verifiable experience with implementing IPM programs. All on-site personnel must understand current pest management practices and be able to make decisions and field diagnoses regarding the use of IPM practices and techniques. The proposal shall present a plan or method for assuring continuity of pest management personnel assigned to this contract, and knowledge and sensitivity to the needs of the schools. The Contractor should understand that quality assurance and daily pest management services are two activities that are separate and distinct from one another, and require sufficient time and manpower.

The Contractor shall designate a Program Technical Supervisor (PTS), who shall have primary responsibility for the conduct of this pest management contract, ensure that all required reports are submitted to the IPM Coordinator on time, and be available for routine and emergency consultation. The following minimum requirements regarding this individual's experience and training shall be provided in the proposal:

1. Resume, including current home address.

2. Current certification or license in California as a Pest Control Applicator or as an Agriculture Pest Control Advisor.

The PTS shall provide on-site supervision to assure safety, carry out coordination and continuity of program services, and fulfill special requests from the IPM Coordinator. The responsibilities of the on-site supervisor will be carried out by the PTS, not the pest management technician. A pest management technician shall provide on-site pest management services

Manner and Time to Conduct Services

Routine services should be performed during the late afternoon hours, Monday through Friday, excluding holidays, except when school is not in session or as specifically approved by the IPM Coordinator. Pesticides shall not be applied while foods are being prepared, served, or put away, or when the school building is open for business. The Contractor shall observe all safety precautions throughout the performance of this contract. Certain areas within some facilities may require special instructions for persons entering the area. Any restrictions associated with special areas will be explained to the Contractor and the IPM Coordinator by the school building liaison. These restrictions shall be adhered to and incorporated into the Contractor's Pest Management Plan and Service Schedule for the school building. All contracted personnel shall wear an identification card in a clearly visible manner during the performance of their duties. Vehicles used by the Contractor or the contractor's personnel shall be identified in accordance with state regulations. The Contractor must park in designated areas in close proximity to each school building. At a minimum, the Contractor shall provide his/her personnel with clean uniforms to be worn while performing their duties. Additional personal protective equipment required for the safe performance of work shall be determined and provided by the Contractor in accordance with California law.

Nonchemical Alternatives

Caulking and sealing pest harborages and pathways is the preferred method for preventing or controlling an infestation and shall be part of the routine IPM services. The Contractor shall make limited applications of approved sealants and other exclusion materials under sinks, as well as around cabinets, pipe chases, windows and doors, exterior areas, etc., in lieu of or to augment other pest management methods. The Contractor shall make recommendations to the IPM Coordinator for any large-scale application (i.e., whole room, exterior of building, etc.) of sealants and other exclusion materials. In addition, the use of vacuum cleaners, mechanical traps, insect light trapping devices, and glue boards used for rodent management should be fully integrated into the day-to-day operations of the program. The Contractor must be proactive at identifying and, in some cases, correcting known or suspected problem areas that provide food, water, harborage, and access for pests in and around the school building. Snap traps, trapping devices, and glue boards used for rodent management or monitoring activities must be intensively maintained. The Contractor shall discard rodents killed or trapped within 24 hours. Trapping should not be performed during periods when maintenance will be delayed by holidays, weekends, etc. Traps shall be placed out of general view and away from any access by children or staff for safety and aesthetic purposes, and located where they will not be affected by routine cleaning procedures. The Contractor shall describe in the proposal their organization's approach to meeting these requirements.

Pesticide Alternatives

Pesticide applications shall be made only to areas of known pest infestation or activity, and where nonchemical control measures, such as traps, caulking, sealing, cleaning, habitat modification, physical, mechanical, and biological control were not successful or are not feasible. Application of pesticides shall not occur until a full inspection has been completed. If chemicals are needed, least-hazardous pesticides and formulations, such as boric acid, silica gels, and diatomaceous earth should be considered whenever possible.

Pesticide applications that may impact the operations or occupants of a school building shall be permitted only during hours when the school building is closed and after all notification procedures have been met. A contingency plan for performing pesticide application in the school building should be part of the Pest Management Plan and Service Schedule. This should include a list of pests, pesticide products, formulations, application methods, timing of application, and other relevant information that may be needed in specific situations and school buildings. The following shall be used as thresholds for the initiation of control actions in the school building:

1. An average of two cockroaches per trap within an area during each service interval.
2. One mouse or rat dropping per room.
3. One rat burrow or runway in outside areas of the school building.
4. Any stinging insect nest within reach from the ground.
5. Recurring problems with other pests, e.g., flies, spiders, or stored product pests, which cannot be resolved using nonchemical techniques.

The Contractor shall minimize the use of and potential exposure to pesticides wherever possible.

For example:

1. Use nonchemical control methods and materials.
2. Use crack and crevice or bait application of pesticides in pest harborage areas.
3. Integrate control methods (i.e., structural repairs, trapping, sanitation, etc.).
4. Pesticide space sprays (including fogs and ultra-low volume applications) will be restricted to unique situations for which no alternative measures are practical or effective. Because notification must be sent home 72 hours prior to spraying, the Contractor must confer with the IPM Coordinator to develop a specific plan.
5. Routine preventive spray treatments are prohibited. The broadcast or barrier treatment of an interior or exterior area with a pesticide must be specifically requested by the Contractor and approved by the IPM Coordinator, prior to performing the treatment. Preventive treatments are acceptable only on a case-by-case basis. The Contractor must provide detailed plans; list the

rationale for the treatment, and the methods of application if preventive treatment is warranted for a specific school building or landscape area. Preventive treatments are subject to review by the IPM Coordinator and can be eliminated at any time.

Reporting

The Contractor's Program Technical Supervisor shall, at a minimum, provide annual written reports to the school district and attend regular meetings with the IPM Coordinator, school administration, school liaisons, and other concerned individuals. These reports and meetings will address all pest management activities provided by the Contractor for each school building and evaluation of the IPM program's progress. These reports should identify school building conditions or personnel practices that require correction by the school district in order to promote the program's overall effectiveness. In addition, the Contractor shall provide monthly service reports to the IPM Coordinator within 15 days following the end of each month. The service reports shall include, but not be limited to, the following:

1. Facilities serviced.
2. Man-hours for each school building for Routine Services.
3. Location, man-hours, and work description of Special, Emergency, and Additional Services.
4. Results of monitoring and inspections, including accepted common names of pests, numbers of each pest, and the location in the school building.
5. Written evaluation of sanitation conditions, structural deficiencies, repairs needed, repairs completed, and immediate and long-term program goals for either resolving pest problems or improving the IPM program within each school building and management area.
6. Identification and listing of pesticides used by common/generic name (no codes), concentration and quantity of finished spray used, and other pest management techniques used for each school building and management area.

Evaluation

Monthly service reports and annual reports will be used by the IPM Coordinator and the Contractor to develop tangible means for evaluating the overall IPM effort in school facilities. The Contractor's Program Technical Supervisor shall meet as needed with the IPM Coordinator to discuss the status of the pest management program and review program activities and reports, or resolve ongoing or special problems. If the school district hires an outside evaluator, the contractor may be required to meet with this person or provide information.

Training

The Contractor shall include, in the proposal, a detailed description of the in-service training programs provided to their personnel, including pertinent documentation and records. In addition, the Contractor should be able to provide training or develop a plan to use outside expertise to provide training on all aspects of IPM program design and implementation to a wide array of school-associated personnel, including school administrators, maintenance and housekeeping staff, the IPM Coordinator and school liaisons, and community members.

Notification

The Contractor shall provide the IPM Coordinator and school liaisons with a list of pesticides that may be used in school before the school year begins. Product labels and Material Safety Data Sheets for all pesticides shall be provided to the IPM Coordinator and made available in the school IPM program logbook for review by school liaisons, parents, and other interested parties. The Contractor shall notify the IPM Coordinator and school building liaisons in advance of all pesticide applications to ensure that all provisions of the State and school district's advance notification policies are met. Although each school district is ultimately responsible for student notification of pesticide use and for sending notification home with students, the Contractor will be responsible for satisfying all legal requirements for posting. The Contractor will notify the IPM Coordinator upon completion of pesticide applications made in and around school buildings.

Inspections

Throughout the duration of this contract, school district personnel will periodically inspect school facilities to determine the effectiveness of the IPM program and Contractor compliance with the contract. Inspection results will be documented in writing and submitted to the Contractor. The Contractor shall initiate actions promptly to correct all deficiencies found. It shall be the Contractor's responsibility to furnish an adequate supply of materials necessary for school personnel to inspect the interior of all rodent bait stations. These materials may include Allen wrenches to loosen and retighten fasteners, keys to open locks, or replacement self-locking plastic ties. Implements to cut plastic ties are not included under this provision.

Purchase of Ancillary Services/Equipment

The Contractor may need to purchase additional equipment or provide additional services to ensure that the IPM program is fully implemented. The school district has the right to negotiate the purchase of ancillary equipment and services with the Contractor and adjust the contract accordingly.

APPENDIX J

Establishing Integrated Pest Management Policies and Programs:

A Guide for Public Agencies

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Establishing Integrated Pest Management Policies and Programs: *A Guide for Public Agencies*

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INTRODUCTION

As a result of growing concerns about health and environmental problems associated with pesticides, public agencies are facing increasing demands from their employees, their clientele, and the general public to explain and justify their use of these materials. Agencies must be able to respond with careful, thoughtful answers. Managing insects, plant pathogens, weeds, rodents, and other organisms that become pests is a complex science; applying pesticides safely and effectively in public areas requires substantial expertise and skill. Responses to the public's questions must communicate an understanding of this complexity and a genuine concern for health and environmental problems.

Adoption of a written policy and procedures for making pest management decisions provides an agency with an effective way to respond to the questioning public and at the same time improves the agency's internal decision-making process, resulting in more efficient, more effective, and safer resolution of pest problems. Involving the public and employees in the development and evolution of a pest management policy can help educate everyone on the potential hazards and benefits of pest management practices.

What Is Integrated Pest Management?

Integrated pest management (IPM) is a pest management strategy that focuses on long-term prevention or suppression of pest problems with minimum impact on human health, the environment, and nontarget organisms. Preferred pest management techniques include encouraging naturally occurring biological control; using alternate plant species or varieties that resist pests; selecting pesticides with a lower toxicity to humans or nontarget organisms; adopting cultivating, pruning, fertilizing, or irrigation practices that reduce pest problems; and changing the habitat to make it incompatible with pest development. Pesticides are used as a last resort when careful monitoring indicates that they are needed according to preestablished guidelines. When treatments are necessary, the least toxic and most target-specific pesticides are chosen. Implementing an integrated pest management program requires a thorough understanding of pests, their life histories, environmental requirements, and natural enemies, as well as establishment of a regular, systematic program for surveying pests, their damage, and other evidence of their presence.

What Are Special Issues for Public Agencies?

For many years, integrated pest management programs have been implemented in agricultural cropping systems. IPM programs in schools, parks, and other public places have been a bit slower to be adopted. Public agencies face infrastructure complexities and public relations issues that are not a concern for individual farmers making pest management decisions.

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Pest management programs in public agencies rely on the coordinated activities of many individuals. Often, several different departments and supervisors are involved in activities that affect pest problems and their management. There may be different supervisors for janitorial staff, pesticide application staff, plant maintenance staff, landscape maintenance staff, and landscape design staff—yet all have critical roles in a pest management program. Each group may have different priorities and a different way of doing business; there may not be effective communication between departments. However, these divisional barriers must be broken down and all employees must be enlisted in a program that shares common goals and approaches to achieve success.

In addition, public agencies must be accountable and responsive to the public. People in the community often want justification for the use of certain types of pesticides and at the same time may demand to know why the agency isn't doing a better job of controlling organisms that they consider pests. A written IPM policy enhances an agency's ability to respond to public concerns and coordinate activities within its bureaucracy.

What Will an Integrated Pest Management Policy Do for Your Agency?

Although the initial reason for developing an integrated pest management policy may be to explain and justify your agency's use or nonuse of pesticides, it will provide many other benefits as well. For instance, a written policy provides procedural guidelines for the agency. There are many federal, state, and local regulations that must be followed when storing, transporting, applying, and disposing of pesticides, and there are specific laws regarding who can recommend pesticides and how applicators must be trained in California. Specific safety equipment and procedures are required for the use of many pesticides. A written policy assures that these laws and regulations are adhered to each time a pesticide is used and helps you document that proper procedures were followed.

Developing and establishing a set policy educates applicators, administrators, other employees, and the general public about when and why pesticides are used and when alternative methods might be adopted. It also helps employees gain a better understanding of their jobs. An IPM policy may reduce your agency's reliance on pesticides, protect the environment, and protect applicators, coworkers, their families, and the public. If problems do arise, the policy provides procedures for immediately handling the problem and helps you to document that your agency acted responsibly.

SETTING POLICY GOALS

The first step in establishing an integrated pest management policy is to determine the goals of your pest management program. Policy goals give your agency a framework on which to base individual decisions. All goals may not be met with each and every decision, but established goals will give your agency a set of priorities to work from. *Goals will vary considerably from agency to agency* according to the function of the agency, public and wildlife access to agency grounds, employee concerns, and political priorities. The overall goal for many agencies would be "to establish a more effective and safe pest management program"; however, this type of general goal is not specific enough to guide decision making. More specific goals might be divided into two categories: political, educational, and public relations goals for policy makers; and operational goals for basing individual pest control decisions.

Goals should be set with input from employees and the general public. Establishing goals is one of the most productive ways that people without technical expertise can participate in the policy-making process. Involving various factions of the community in policy development is a good way to garner widespread support for the program and policy later on. Pest management policy goals differ with the function of different agencies; examples of possible goals follow.

Examples of Political-Educational Goals

- Encourage employees to first consider alternatives to pesticides.
- Keep citizen complaints at or below current levels through effective practices and public education.

Examples of Operational Goals

- Design a written plan for implementing IPM procedures throughout the facility and for individual pests.
- Ensure that the public agency's governing board (supervisors, trustees, directors) is kept informed as to the progress of the IPM program. The board's support and encouragement can assure the program's presence and fiscal health.
- Establish procedures (e.g., through a technical review committee and periodic reevaluations) for assuring that the latest information is incorporated into pest management decisions.
- Develop procedures for allowing public input without disruption of the overall program.
- Make information accessible to the public and employees regarding pesticides used and areas treated.
- Ensure that applicators are educated regarding current pesticides, their hazards, and applications.
- Educate employees and the public about pest management problems and solutions.
- Develop protocols for plant inventory and pest problem survey.
- Establish monitoring programs and evaluative criteria to measure control success.
- Maintain pests at levels that prevent them from becoming a health hazard.
- Eliminate fire hazards (such as tall dry grass or dead trees) in a timely manner.
- Reduce or eliminate all use of pesticides in CDFA category I, II, or III (agency choice).
- Establish and maintain pesticide use reporting and recordkeeping.
- Provide employees with pest management training, including diagnostic skills and use of alternative pest control methods.
- Establish and maintain records of pest occurrence and levels at which they become a problem.
- Identify and evaluate cultural and environmental conditions on the grounds that seem to encourage pest problems.
- Use the safest effective practices whenever economically feasible.

PROCEDURES FOR DESIGNING AN IPM PROGRAM

Once policy goals are set, persons with pest management expertise within (and perhaps also outside) your agency must establish reasonable procedures for meeting these goals. At first, some operating guidelines will be crude, but you can refine them with time as your experience grows. However, it is important to have established procedures so you can document and measure their success and improve them with time. The procedures listed below are intentionally generic because of the great variety of pest management situations. Pest control procedures must be developed on a pest-by-pest basis, and procedures will change and evolve over time. You can get help by consulting the resources at the end of this publication, talking with University of California Cooperative Extension staff, consulting private pest management consultants, or talking with other agencies with similar problems. Remember to keep your policy goals in the forefront and to regularly document and reevaluate your program. Keep up with new ideas and practices through continuing education and professional publications.

The success and sophistication of your IPM program will depend on the experience, skill, education, and enthusiasm of your employees. Take these factors into account when establishing procedures. Don't expect employees to perform new tasks without encouragement and training. You may need to bring in outside expertise to assist in the first season of a new program. Expect to implement change over time, incorporating a few major component at a time.

Step-by-Step Procedures for Developing an IPM Program

1. Identify all potential pests (including all life stages) in the system. Verify damage symptoms associated with pests and identify natural enemies. For plant pests, this will require identifying plant species in the management area and developing pest lists for each host. Train all pest management personnel to accurately identify beneficials as well as major pests and their damage, and to seek help when they can't make a conclusive identification. Have materials (e.g., a field manual or identification texts such as those listed in the resources on p.11) and tools (e.g., a dissecting microscope and hand lens) available to assist in pest identification. Make provision for identifying new pests as they are observed (see step 9).

2. For each pest, establish monitoring guidelines. These may be crude at first but can be improved with experience. Monitoring methods vary from pest to pest (for more information, see the resources on p.11), but all involve regular (e.g., weekly) checking, visually or with traps, for pests or damage symptoms, or other evidence of pest presence (e.g., feces); methods also involve some way of quantifying observations. Also provide for monitoring of beneficials and natural enemies. Overall, the objectives of a monitoring program are to pinpoint precisely when and where pest problems may become intolerable and to determine the effectiveness of treatment actions. To determine the need for treatment, the objectives must be used with action thresholds, as discussed in step 3.

3. Establish injury levels and action thresholds for each individual pest species before making any treatment. An injury level is the pest population size (e.g., 10 aphids per leaf or 2 cockroaches per trap) that is associated with intolerable damage. Action thresholds are the set of conditions required to trigger a control action—usually a pesticide application.

Determine the infestation levels that will be intolerable to people or to structures or that will cause unacceptable damage at various times of the year, plant growth stages, situations, and so on. At the same time, devise a monitoring plan for detecting these pest levels and determining when to treat. Over time you will refine the injury levels and action thresholds; however, treatment is usually required when

- a regular monitoring program indicates that the pest population will reach the injury level if left untreated; and
- biological or environmental factors cannot be expected to reduce the pest problem within a reasonable time; and
- treatment cost and health and environmental hazards are considered less than the potential pest damage.

4. **Establish a recordkeeping system.** Good records are essential for evaluating and improving your IPM program and for reference when the public wants to know how you handle certain types of pests. Any recordkeeping system should include observations such as

- identity of the pest (to species if possible) and how the identification was made
- the size (density) of the pest infestation
- the geographic distribution of the pest problem in the managed area (a map of your facility can be useful for this)
- complete information on how you treated the problem, including what, how much, where, when, who, cost, application difficulties, and the effectiveness of treatment in solving the pest problem (short-term and long-term)
- the side effects of the treatment on nontarget species
- public complaints or other problems that arise, and positive feedback

5. **Develop a list of acceptable management strategies for each pest.** The preferred methods in an IPM program *prevent* pest problems and therefore eliminate the need for pesticide applications. These methods might include modifying structures or landscaping to be less conducive to pest survival, using pest-tolerant or pest-resistant cultivars, using cultural practices (such as mulches or mowing and the use of pruning and planting times that discourage pests), and educating the public to be more tolerant of pests. Encouragement of naturally occurring biological controls can be very important; in some cases, barriers, traps, or mechanical removal can be effective. Develop a list of pesticides that are effective against each pest but are least disruptive to the environment—for instance, soap sprays, microbials, botanicals, oils, and synthetic pesticides with low LD-50 and short persistence. Investigate and document the potential for using low rates, spot treatments, and other selective ways to integrate pesticides into an IPM program that is least disruptive to biological control agents and nontarget organisms. For instance, using bait stations or other formulations that reduce exposure to humans or nontarget organisms is an important way to reduce potential risks.

6. Develop specific criteria for selection of pest management methods. Make the criteria known to employees and the public. Although all criteria may not be met in every case, choices should meet the majority of the following requirements:

- least disruptive of natural controls
- least hazardous to human health
- least toxic to nontarget organisms and least damaging to the general environment
- most likely to produce permanent reduction of the pest
- easiest to carry out effectively
- most cost-effective in the short- and long-term

For instance, avoid the common practice of regularly scheduled perimeter sprays to keep invading species such as ants, beetles, spiders, or earwigs out of buildings. This strategy does not provide a long-term solution to a problem and may kill beneficials and promote pesticide resistance. Structural changes, habitat reduction around buildings, and the use of baits can provide long-term control in many cases.

7. Develop guidelines to be followed each time a pesticide is used. Prepare a checklist to be used each time an application is made. Important items on the checklist should include:

- choosing the safest material that is effective
- considering label signal words, persistence, impact on nontargets, and potential chronic human health effects
- considering the potential for treating only the most seriously infested areas (i.e., spot treatments) to allow for survival of natural enemies (this works for some insects and mites only)
- making sure the pesticide is registered in California for the situation and that you are aware of all laws regarding its use
- if required, making sure you have in hand a written recommendation for using the pesticide made by a licensed pest control adviser
- checking the pesticide label to make sure all precautions and legal requirements are being carefully adhered to
- making sure all safety equipment and clothing are used
- verifying that the person doing the application is certified and qualified to handle the equipment and material chosen and that the person has been adequately trained
- after the application, monitoring the pest population to see if the treatment was effective
- keeping written records
- obtaining the Material Safety Data Sheet (MSDS) for the pesticide from the manufacturer
- making sure your application equipment is appropriate for the job and calibrated
- being prepared for all emergencies and knowing whom to call for help and interim measures to take before help arrives

8. Designate a person to be responsible for each step along the way. These are the people (e.g., job titles) who will be responsible for making decisions, carrying out the various pest management and emergency operations described in your policy, and regularly evaluating the effectiveness of the program.

9. Develop a list of resources. Know where you can go when information or outside help is needed. Include resources for pest identification, pesticide recommendations, and information about pesticides, pest management, and handling emergencies. Build a library and have employees participate in training and continuing education programs on a regular basis. (See the resources on p.11.)

10. Consider your IPM policy to be a "living document" that changes as you acquire experience and new information. Establish an oversight committee that includes persons with toxicological and pest management expertise to assist with initial review of procedures and future changes in the policy. Review the program regularly (e.g., annually). Involve environmental organizations, worker health advocates, and other interested members of the public or employee representatives from your facility in the development and revision of the IPM policy.

Outside Contractors

Some agencies have no staff or limited staff to devote to pest management activities. Some do not have staff with expertise or appropriate licenses to carry out certain pest management activities. In these cases, agencies will want to hire outside contractors for pest management services.

Contractors differ in their skills and experience, and it is important to hire a company that is reliable and knowledgeable about IPM practices and the goals of your IPM program. Performing appropriate preventive and monitoring activities may take extra time, so the lowest bidder may not always be the best company for your job. Be sure to specify needed IPM practices clearly in your contract and formalize a good communication system. Hire contractors who have appropriate pesticide application and pest control adviser licenses and training and who also have experience in IPM in situations such as yours. Ask them to provide you with their license number.

The first step in hiring a contractor is to prepare a request for qualifications (RFQ) that will allow you to prescreen and ensure that only qualified contractors submit proposals for the bid process. Next, prepare a request for proposals (RFP) that details the terms of your IPM policy. Evaluate the responses to the RFP according to the contractor's ability to meet the goals of your program. As part of the pest management contract, develop a quality assurance form (QAF). The QAF is filled out by the contractor each time a service is provided. It should detail information on pest sightings, sanitation and structural concerns, pesticides applied, traps or monitoring stations installed, pesticide use or other regulatory forms filed, and any additional pest management concerns.

BUILDING SUPPORT FOR YOUR IPM PROGRAM WITHIN AND OUTSIDE YOUR AGENCY

Once an IPM policy has been adopted by a city council, school board, or other policymaking body, it falls to agency staff or pest control contractors to implement the policy. Change never comes easily. There are a number of predictable obstacles within an agency—both psychological and institutional—to be overcome when initiating IPM programs. At the same time, even if the public has been involved with development of a policy, there are likely to be occasional complaints and controversies, especially as pests, pest control practices, and public concerns change.

Psychological Barriers to IPM Adoption

Psychological resistance to change

The problem: When pest control personnel are asked to make pest management decisions in a new way and to use new methods, they may feel that there is a negative implication regarding their past performance.

How to address it: Many factors contribute to the need to change pest management practices. Most of these factors are beyond the control of the individual pest manager. They include loss of effectiveness of many pesticides as pests develop genetic resistance; increased availability of less-toxic products or techniques; increased requirements for documentation, licensing, certification, and continuing education; and public concern about adverse health and environmental effects of pesticides. Adoption of IPM methods enables pest control professionals to respond to these forces for change and at the same time achieve cost-effective control of pests.

Loss of authority

The problem: Adopting an IPM approach may engender fear of many kinds of losses, including loss of personal authority or supervisory authority. In the first case, individuals may fear that their experience in the field will become devalued, particularly if their expertise has been in pesticide application. In the second case, supervisors may fear that the system will become more efficient and they will lose positions.

How to address it: Successful IPM implementation enhances both personal and supervisory authority. Many of the new, less-toxic pest control materials such as pheromones, microbial and botanical pesticides, insect growth regulators, and biological controls require application skills and equipment that are similar to conventional pesticides, and workers can readily learn necessary modifications to conventional practices. Mastery of IPM monitoring skills enhances the professionalization of pest management and can lead to upgrading job classifications. In terms of supervisory authority, IPM programs provide managers with greater decision-making responsibilities and an increase in the flexibility of staff assignments. For example, by emphasizing monitoring rather than prophylactic pesticide applications, staff time previously spent spraying can be redirected to other tasks, increasing overall productivity within a department.

Imagined difficulty in learning new technology

The problem: The techniques used in IPM may initially appear to require conceptual and operational skills beyond those of current staff.

How to address it: This fear can be overcome by building staff training into the IPM implementation program and by establishing a transition period during which pest management personnel experiment with and fine-tune IPM methods. Transition new practices in a step-by-step fashion so that not all changes are made at once.

Fear of IPM program failure

The problem: Supervisory personnel may believe that the IPM program will not work for them even though it has been successful for a nearby agency.

How to address it: IPM programs are specifically designed for the particular circumstances of each location, such as the plants and pests involved, microclimates at the site, and management history. While the IPM decision-making process remains the same no matter what the pest or site, the tactics and products used may vary greatly from one location or circumstance to another. This flexibility usually assures an appropriate solution to the pest problem.

Institutional Barriers to IPM Adoption

Fear that IPM means no access to pesticides

The problem: Some people think that IPM means never using chemical controls.

How to address it: While IPM definitely encourages alternatives to pesticides when feasible, chemical controls are used when necessary. However, in an IPM program, pesticides that are least disruptive, most selective to specific pests, and rapidly biodegradable are preferred over common, broad-spectrum materials. For instance, the microbial insecticide *Bacillus thuringiensis*, a naturally occurring bacteria that kills only certain groups of pest insects, is an example of the type of pesticide preferred for use in IPM programs. When chemical controls are used in an IPM program, every effort is made to reduce human and nontarget exposure, for instance, by putting materials in bait stations or within walls or by "spot-treating" specific areas rather than broadcast spraying.

Fear that IPM is more expensive than traditional pest control

The problem: Until agencies have experience with IPM, they may expect that it will cost more than their current program.

How to address it: While there are short-term start-up costs for any new technology, in the long run IPM has often proven to be more cost-effective than a strictly chemical control program. When possible, IPM programs substitute information gathering (monitoring) in place of other pest control activities. This can be very cost-effective. For example, by monitoring the 1,100 elm trees in their city rather than prophylactically spraying them against elm leaf beetles, the city of San Rafael, California, found that only a small portion of the trees required treatment. As a result, the city saved $1,400 (including costs of monitoring) in the first year of its IPM program compared to the previous year when all trees were sprayed.

Also, IPM methods emphasize reducing the source of pest problems (e.g., eliminating pest habitat and food sources) rather than treating the pests themselves (e.g., spraying). This type of pest prevention program is more cost-effective than a continuing program of pest reduction that does not address the underlying cause of the infestation. For example, by permanently reducing habitats for rats (i.e., by filling rat holes with concrete, changing the design of garbage cans, and increasing frequency of garbage pickup), the National Park Service was able to permanently reduce rat populations in certain parks. Previous rat control programs that had relied on poison baits had not been successful despite large expenditures of labor and money.

Lack of in-house IPM expertise

The problem: Agency staff may be unfamiliar with IPM and not know where to go for information.

How to address it: While it is true that IPM education and training resources are not as widely available as those for chemical controls alone, good resources can be found in any community. Many agencies have found it feasible to hire an IPM specialist to work as a consultant to in-house pest control staff during the initial year or two of IPM implementation, or to create an IPM coordinator position and recruit nationwide. Increasingly, cooperative extension advisors or agents, college horticultural or entomological faculty, pest control advisers, and a nationwide network of nonprofit organizations involved in pest management, sustainable agriculture, and environmental protection are able to provide IPM information and advice. Periodicals and Web sites providing practical technical advice on IPM methods for specific pest problems are increasingly available. The resources at the end of this publication will assist anyone attempting to implement IPM programs.

SOME FINAL HINTS FOR IMPLEMENTING AN IPM PROGRAM

The following suggestions will help overcome barriers and smooth the transition to IPM implementation.

Mandate staff training in IPM. When writing the IPM policy document, include a requirement for the continuing education of pest management personnel. Ensure that budgetary allocations are made to assist them in obtaining the information, skills, and equipment they need to carry out the policy.

Start small. Begin IPM implementation in one location (e.g., one lawn in one park; one kitchen in one school) and include short-term objectives. For example, when dealing with a number of pest problems, identify one of the pests likely to respond quickly to an IPM approach so that a short-term objective can be realized. Test the IPM methods and fine-tune them. When the program is working successfully in one area or against one pest, expand the program.

Don't change everything at once. To the maximum degree possible, retain communication and accountability procedures already in use. Tailor new recordkeeping and reporting forms to fit existing agency formats. Recycle existing equipment to uses consistent with IPM methods rather than immediately eliminating the equipment.

Share the process. Involve all pest management personnel in the day-to-day IPM program process as early as possible so that they will understand and support the program during the sometimes difficult transition period.

Emphasize communication and plan for future training. During the IPM transition period, keep all personnel informed about what is planned, what is happening now, the expected outcome, and what will happen next. Prepare written records and visual aids that will remain in the agency when persons associated with development of the IPM program are no longer there.

Build in a reward system. Identify benchmark objectives (e.g., testing of mechanical weed control methods in one park during a 3-month period or a 10 percent reduction in pesticide use in the first year). Encourage staff to achieve objectives (e.g., a letter of commendation from agency head, recognition at an awards ceremony, an article in an agency bulletin, merit pay increase).

Publicize the program. Develop good rapport with agency public relations personnel and with the local news media. Include field and management staff at photo and interview sessions about the IPM program.

Involve the community. Form an IPM advisory committee composed of interested organizations, members of the public, and pest control professionals. They can help make IPM implementation a budgetary priority in the agency, can donate or locate resources that may not otherwise be available to the agency, and may add needed expertise and experience to the process.

RESOURCES FOR AGENCIES DEVELOPING IPM POLICIES

General Information

In addition to the resources listed in this section, other agencies that deal with problems similar to yours, as well as pest management consultants, can be valuable sources of general information.

The University of California County Cooperative Extension offices are a valuable resource. In California, check your phone book under University of California or Cooperative Extension; or, see the University of California Agriculture and Natural Resources Web site, http://ucanr.org/.

Professional Organizations

- Association of Applied IPM Ecologists (AAIE) http://aaie.net/
- California Agricultural Production Consultants Association (CAPCA) http://www.capca.com/
- California Weed Science Society (CWSS) http://www.cwss.org/
- Pesticide Applicators Professional Association (PAPA) http://www.papaseminars.com/

Web Sites

The University of California Statewide IPM Program Web site at http://www.ipm.ucdavis.edu has information on managing and identifying pests of landscape, structures, agricultural crops, and pests of medical importance. There are links to pages related to pesticide toxicity, water quality, and other related resources.

The California Department of Pesticide Regulation IPM for Schools Web page at http://www.schoolipm.info/ has complete information on California's IPM in Schools Program as well as links to other information relating to managing pests in public buildings and landscapes.

The U.S. EPA Region 9 has an IPM manual for schools, *Integrated Pest Management for Schools: A How-to Manual* on its Web site http://www.epa.gov/region09/toxic/pest/school/. The manual includes appendixes that include IPM contract performance specifications and sample monitoring forms.

Many (but not all) pesticide Material Safety Data Sheets (MSDS) and labels are available at the Crop Data Management Systems Web site: http://www.cdms.net/manuf/manuf.asp

Other useful Web sites related to pesticides include:

- National Pesticide Information Center http://npic.orst.edu/links.htm
- Extoxnet (Extension Toxicology Network) http://ace.orst.edu/info/extoxnet/ghindex.html
- U.S. EPA Reregistration Fact Sheets http://www.epa.gov/pesticides/

Books and Other Literature

A free catalog is available from University of California Agriculture and Natural Resources Communication Services (6701 San Pablo Avenue, Oakland, CA 94608-1239; http://anrcatalog.ucdavis.edu; phone 1-800-994-8849/510-642-2431) that lists many publications of value in managing pests, including those listed below as University of California ANR publications.

Dreistadt, S. H. 1994. Pests of landscape trees and shrubs: An integrated pest management guide. University of California ANR Publication 3359.

Flint, M. L. 1998. Pests of the garden and small farm: A grower's guide to using less pesticides. 2nd ed. University of California ANR Publication 3332.

Flint, M. L., and P. Gouveia. 2001. IPM in practice: Principles and methods of integrated pest management. University of California ANR Publication 3418.

Mallis, A. 1997. Handbook of pest control. 8th ed. Cleveland, OH: Mallis Handbook and Technical Training Company.

Marer, P. J. 1991. Residential, industrial, and institutional pest control. University of California ANR Publication 3334.

O'Connor-Marer, P. J. 2001. The safe and effective use of pesticides. 2nd ed. University of California ANR Publication 3324.

Salmon, T. P., and R. E. Lickliter. 1984. Wildlife pest control around gardens and homes. University of California ANR Publication 21385.

Whitson, T. D., L. C. Burrill, S. A. Dewey, D. W. Cudney, B. E. Nelson, R. D. Lee, and R. Parker. 2001. Weeds of the west. 9th ed. Western Society of Weed Science. Available from UC ANR Communication Services as Publication 3350.

Zavala, M. 1991. The illustrated guide to pesticide safety/ Guía ilustrada para el uso seguro de pesticidas. Instructor's Edition. University of California ANR Publication 21489.

FOR MORE INFORMATION

Visit our online catalog at http://anrcatalog.ucdavis.edu. You can also place orders by mail, phone, or fax, or request a printed catalog of publications, slide sets, videos, and CD-ROMs from

University of California
Agriculture and Natural Resources
Communication Services
6701 San Pablo Avenue, 2nd Floor
Oakland, California 94608-1239

Telephone: (800) 994-8849 or (510) 642-2431
FAX: (510) 643-5470
E-mail inquiries: danrcs@ucdavis.edu

An electronic version of this publication is available on the DANR Communication Services Web site at http://anrcatalog.ucdavis.edu.

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UC PEER REVIEWED

This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by the ANR Associate Editor for Human and Community Development.

APPENDIX K

How to Collect and Preserve Specimens for Identification

You can get help with pest identification from your County Department of Agriculture and University of California Cooperative Extension offices (look in your phone book under County Government). Often the entomology or botany departments of local universities and junior colleges can help.

If your pest problem is common in your area, the identification specialist may be able to confirm your identification over the phone just from your description of the organism and/or the damage it caused. Often, however, they must inspect the specimen directly.

Collecting Insects and Mites for Identification

Whenever possible, ask how your identification specialist would like the specimens preserved, and try to collect more than a single specimen. If you aren't able to ask about preservation before you collect, the following are useful guidelines.

Larger insects (those larger than aphids) or insects with hard bodies should be placed in a plastic container, such as a pill bottle, film canister, or other container with a snap-on lid. Crumpled tissue or cotton in the container can keep the insects from rattling around and losing body parts. Mail or hand-deliver the container to the identification specialist. If you are mailing specimens, it is a good idea to put the container in the freezer overnight to kill the insects before they go through the mail.

Very small insects or mites can be collected on plastic tape. Gently pat the insect or mite with the sticky side of the tape and secure the tape to a sheet of white paper. Be careful not to clutter the tape with extraneous debris. The paper with the tape can be mailed or hand- delivered to the identification specialist. Alternatively, insects and mites, even soft-bodied species such as aphids, can be left to dry out in a container and the identification specialist can rehydrate them for study later.

Collecting Plant Specimens for Identification

If you want to have a damaged plant inspected or a weed identified, place the plant between two sheets of paper and enclose in a file folder or place between two pieces of cardboard. If you are unable to deliver the specimen in person immediately, it is likely to shrivel or mold. In that case, use the process outlined below.

Preserving a Plant Specimen

Lay the plant between two sheets of writing paper and place on a flat surface. Try to spread the plant out so that leaves and stems are not covering each other. On top of the paper set several heavy, flat objects (such as phone books) large enough to cover the plant. Press the plant in this manner until it is completely dry. At this point, the specimen can be mailed in a file folder inside a padded envelope.

Plants preserved in this manner can also be kept in a file for future reference regarding weeds, pest damage symptoms, etc. To preserve the plant for your own file, place it on one half of the inside of a file folder. Cut a piece of clear contact paper the size of half the file folder. Separate the backing from the contact paper and lay the contact paper over the plant and folder, pressing out air bubbles by moving your hand from the inside outward. Write the name of the plant (if known), the date, and the location where it was collected on folder.

Keeping a Record

If you send a sample specimen for identification, we suggest you keep another for your own reference, because samples are rarely returned. Along with the sample, you should send records of potentially important information about the situation or problem surrounding the specimen. Keep a copy of this information for yourself. We suggest you follow this format:

- date the specimen was collected
- place or address where the specimen was collected and type of area (e.g., lawn, parking lot, etc.)
- specific area where the specimen was collected (e.g., "north side of building 1A," "under a stone," etc.)
- host plant, if the insect was found on a plant

The Pest Management Assessment Tool is meant to help consultants, pest control operators, or IPM Coordinators understand the pest management system at a school. This includes the organizational structure, pest management policies, key pests and how they are managed, and conditions conducive to pest problems. The Tool can help the assessor remember what to look for and what questions to ask during an initial pest management assessment.

The Assessment Tool can also be used to train school personnel in monitoring procedures and can help remind the IPM Coordinator of the elements of an effective IPM program.

This Assessment Tool consists of a number of forms, all of which can and should be altered to fit your particular situation. Computer software exists that can help you create and modify forms. With an electronic scanner, you can scan in forms from other sources and modify them to fit your needs. You can also find these forms online at www.schoolipm.info.

Forms:

1. Pest Management Summary Form
2. Pesticide Use, Storage, and Disposal Checklist
3. Pest Inspection/Sanitation Report
4. Pest Proofing/Repairs Needed Inside
5. Pest Proofing/Repairs Needed Outside

Pest Management Summary Tool

Date completed________________________

School #1 ____
School #2 ____
School #3 ____

GENERAL SCHOOL INFORMATION

School Address ____
School District ____________________________ Last Day of School ________________________
Superintendent ____________________________ Phone Number ________________________
Address ____
Address ____
email ____________________________ No. of years in position ________________________
Principal ____________________________ Phone number ________________________
email ____________________________ No. of years in position ________________________
PTA President ____________________________ email ________________________
No. of Real Buildings ____________________________ No. of Portables ________________________

POLICY AND PLANNING

IPM Policy for District? ____
Pest management budget? ____
Cost accounting for pest management? ____
IPM Plans for key pests? ____
Annual report on pest management? ____
Approved pesticide list? ____
Restricted pesticide list? ____
Other pesticide lists? ____
Policy on personal ownership/use of pesticide? ____
In compliance with State worker health and safety requirements?________________________
What is the attitude toward trial and error and experimentation in pest management:
Attitude of managers? ____
Attitude of administration? ____
Are pest prevention techniques used? ____
Are they encouraged? ____
Are pest management implications considered prior to new construction or building renovation? ______
Are pest management implications considered prior to new landscaping or landscaping renovation? ___

TRAINING

Training in pesticide safety, use, and disposal? ______

Training in pest management is required? ______

How much? ______

IPM training included? ______

How much? ______

Who provides training? ______

Continuing education units offered? ______

Opportunities for pursuing State licensing (QAC, QAL)? ______

MONITORING/RECORDKEEPING

How often and under what circumstances is the campus inspected for pest problems or conditions conducive to pests? ______

Monitoring program in place for key pests? ______

Monitoring data recorded? ______

How: By hand? ___ Computerized? ___

Where are records kept?

How are pest sightings or complaints about pests relayed from teachers and admin. staff to pest management staff? ______

Are sightings and complaints recorded? ______

Are pest control treatments evaluated for effectiveness? ______

Are pest control strategies modified to reflect the evaluation? ______

COMPLIANCE WITH THE HEALTHY SCHOOLS ACT (AB2260)

School designee/IPM Coordinator selected? ______

(Include name and other information below under "Organizational Structure for pest management.")

Annual pesticide use notification letter sent? ______

Number of people on registry? ______

People on registry notified for each pesticide application (including those of contractor)? ______

Pesticide applications posted? ______

ORGANIZATIONAL STRUCTURE FOR PEST MANAGEMENT

Pest management activities carried out by district staff or school staff? ______

IPM Coordinator ______

Address ______

Address ______

Phone number ______ Fax number ______ email ______

No. of years in position ______ Licenses held ______

School Designee (if different from above)

Address ______

Phone number ______ Fax number ______ email ______

No. of years in position ____________________ Licenses held ______________________________
District Supervisor for Maintenance (if different from above) ______________________________
Address ____
Address ____
Phone number ________________ Fax number ________________ email __________________
No. of years in position ____________________ Licenses held ______________________________
Other Important District Managers ____
Main Groundskeeper ______________________ Phone number ____________________________
No. of years in position ____________________ Licenses held ______________________________
Total No. of Grounds staff _________________ No. holding licenses _______________________
Head CustodianPhone number ______________No. of years in position ___ Licenses held ____
Total No. of Custodians ____________________No. holding licenses _______________________
Outside Contractors ____
Address ____
Address ____
Contact name ____________________________Phone number ____________________________
Outside contractors provide district/school with periodic reports? ______________________
What frequency? ____
Work orders generated by ____
Work orders approved by ____
Pesticide use records stored ____

FOOD PREPARATION/SANITATION
Cafeteria/Kitchen? ____
Where do children eat? ____
Food Prep on Site? ____
Food in classrooms? ____
Pets in classrooms? ____
Lockers in school? ____
Sanitation for lockers? ____
Dumpster pickup schedule ____
Dumpster clean? ____
Lid on dumpster? ____

LANDSCAPING
No. and size of fields ____
No. and size of lawns ____
Other landscaping of concern ____

KEY PESTS

Insects in and around Structures ______________________________

Primary pest ______________________________

Pesticide(s) used ______________________________

Other control methods ______________________________

Secondary pest ______________________________

Pesticide(s) used ______________________________

Other control methods ______________________________

Other/Comments ______________________________

Conditions conducive to insect pests. (list all) ______________________________

Vertebrates (other than birds) ______________________________

Primary pest ______________________________

Pesticide(s) used ______________________________

Other control methods ______________________________

Secondary pest ______________________________

Pesticide(s) used ______________________________

Other control methods ______________________________

Other/Comments ______________________________

Conditions conducive to vertebrate pests. (list all) ______________________________

____

____

Bird pests ______________________________

Pesticide(s) used ______________________________

Other control methods ______________________________

Other/Comments ______________________________

Conditions conducive to bird pests. (list all) ______________________________

Other structural pests ______________________________

Pesticide(s) used ______________________________

Other control methods ______________________________

Turf Pests (other than weeds) ______________________________

Primary pest ______________________________

Pesticide(s) used ______________________________

Other control methods ______________________________

Secondary pest ______________________________

Pesticide(s) used ______________________________

Other control methods ______________________________

Other ______________________________

Conditions conducive to turf pests. (List all) ______________________________

____

Weed Pests ___

Primary weed ___

Herbicide(s) used ___

Other control methods ___

Secondary weed ___

Herbicide(s) used ___

Other control methods ___

Tertiary weed ___

Herbicide(s) used ___

Other control methods ___

Additional weed(s) ___

Herbicide(s) used ___

Other control methods ___

Conditions conducive to weeds. (List all) ___

___

Other landscaping pests ___

Pesticide(s) used ___

Other control methods ___

Pesticide Use, Storage, and Disposal Checklist ___

Pesticide Use, Storage and Disposal Checklist

General

❒ Pesticides used in school are registered in California.

❒ Copy of each appropriate label is available at use site.

❒ Applicators using restricted materials are licensed or certified to apply the material or under the direct supervision of someone who is.

❒ Records kept of pesticide use. Records must include the following to comply with the Healthy Schools Act:

- date and place of application
- amount used
- product names
- active ingredient(s)
- manufacturer's name
- U.S. Environmental Protection Agency's product registration number.

❒ Pesticide use records kept for 4 years in an area accessible to the public.

Training

❒ School keeps written records of applicator training.

Applicators are trained in at least the following:

- Meaning of precautionary statements on the pesticide label
- Routes pesticides can enter the body and the signs and symptoms of pesticide over-exposure
- Emergency first aid and how to obtain emergency medical care
- Safety requirements and procedures
- Environmental concerns such as drift, runoff, and wildlife hazards
- Applicable regulations and the Material Safety Data Sheet
- The location of the completed Hazard Communication for Employees Handling Pesticides in Noncrop Settings (Pesticide Safety Information Series N-8 from the Department of Pesticide Regulation Appendix P or your County Agricultural Commissioner).

Equipment

❒ Equipment in good repair and safe to operate.

❒ Equipment for mixing, loading, transferring, or applying pesticides is inspected before each day of use.

Emergency Plans

❒ List of emergency phone numbers in vehicles and/or an accessible area near a phone.

❒ List of first aid procedures in vehicles and/or at use sites.

❒ Name, address, and phone number of facility at which medical care is available is prominently posted in vehicles and/or at use sites.

Storage and Disposal

❒ Pesticides with signal words "Danger" or "Warning" stored in locked area that is dry, separate from food and feed, and away from children and pets.

❒ Sign reading "Danger: Poison Storage Area. All unauthorized persons keep out." posted on storage area.

❒ Pesticides with signal word "Caution" stored in dry areas away from children, preferably under lock and key.

Pest Inspection/Sanitation Report

Date ______________________ School ______________________

Building#/Location ____

Inspector ______________________ Inspection Type ____________ Initial _____

Quality Control ______________________ Routine ______________________

Evidence of Infestation(s) ____

Pest ______________________ Location ______________________

Pest ______________________ Location ______________________

❒ Ants ❒ Fleas ❒ Cockroaches ❒ Stored Prod. Pests ❒ Mice ❒ Pigeons ❒ Rats

❒ Other ____

Sanitation Survey

Food Preparation: ❒ Yes ❒ No Receiving: ❒ Yes ❒ No

❒ Equipment clean
❒ Floors clean
❒ Appliance drip pans clean
❒ Area neat and tidy; no clutter
❒ Floors clean
❒ Empty boxes stored in cold storage
❒ Floor drains clean
❒ Empty boxes stored away from kitchen
❒ Sink drains clean
❒ Public and Staff Areas
❒ Counters/Tables clean
❒ Restrooms clean
❒ Food stored pest-proof containers
❒ Plumbing in good repair; no leaks
❒ Perishables stored in refrigerator
❒ Locker room clean
❒ Garbage removed daily at end of day
❒ Locker room free of food and food waste
❒ Spillage cleaned regularly
❒ Employee lounge clean
❒ Floors and counters dry; no standing water
❒ Food stored properly in lounge
❒ Plumbing in good repair; no leaks
❒ Food stored properly in classrooms
❒ Windows/doors screened
❒ Trash removed daily before end of day
❒ Gaps around/under doors or windows repaired

- ❒ Janitorial closet clean
- ❒ Pest proofing needed
- ❒ Pest Proofing needed
- ❒ Storage Areas
- ❒ Exterior
- ❒ Floors clean
- ❒ Dumpster/garbage cans cleaned weekly
- ❒ Floor drains clean
- ❒ Dumpster/garbage cans have lids
- ❒ Food stored in pest-proof containers
- ❒ Lids closed on dumpster/garbage cans
- ❒ Recyclables cleaned before storing
- ❒ Garbage area downwind from kitchen
- ❒ Spillage cleaned regularly
- ❒ Dumpster/Garbage area clean
- ❒ Items stored 6" to 8" off floor
- ❒ Garbage removed at least weekly
- ❒ Items stored 12" to 18" away from wall
- ❒ Pet waste removed daily
- ❒ Stock rotated
- ❒ Loading dock clean
- ❒ Area neat and tidy; no clutter
- ❒ Gaps under/around doors repaired
- ❒ Pest proofing needed
- ❒ Area is trash- and weed-free
- ❒ Other ______________________________
- ❒ Area is dry; no standing water
- ❒ Pest proofing needed
- ❒ Comments/Recommendations ______________________________

____

____

Pest Proofing/Repairs Needed Inside

Date ______________________ Inspector ______________________

Facilities Manager ______________________________________

Building#/Location/Address ______________________________

For each repair, specify location and action needed. Draw a floor plan on the reverse side of this form to clarify locations. State priority for each work item.

■ Seal holes in wall around pipes, cables, and wires

■ Seal cracks and crevice with caulk or paint

■ Seal other holes 1/4" or larger

■ Fix leaky plumbing

Doors ❒ Repair ❒ Replace ❒ Weather-strip ❒ Add kickplate

Other ______________________________________

❒ Correct excessive moisture problems

❒ Remove clutter

❒ Organize storage rooms/closets

❒ Store rodent nesting material (fabric, paper, rug scraps, plastic, insulation) in rodent-proof containers

❒ Clean drains

❒ Screen drains

❒ Cap drains in basement floors

❒ Store human and pet food in pest-proof containers

❒ Improve sanitation

❒ Dispose of insect- or rodent-infested goods

❒ Remove fecal matter (rodents, bats, birds)

❒ Sanitize animal droppings

❒ Investigate secondary pest potential from rodent infestation (e.g. fleas, mites)

Floor Plan

Building location ____

Draw a floor plan and mark locations for repairs or pest-proofing.

Pest Proofing/Repairs Needed Outside

Date ______________________ Inspector ______________________

Building#/Location/Address ______________________________________

For each repair, specify location and action needed. Draw a building plan on the reverse side of this form to clarify locations. State priority for each work item.

- ■ Cut vegetation back from building walls at least 18 inches
- ■ Remove ivy or other vines from sides of buildings or nearby trees
- ■ Trim back tree branches that touch or rub against building
- ■ Seal /repair air conditioning units
- ■ Seal holes in wall around pipes, cables, and wires
- ■ Seal other holes 1/4 inch or larger

Doors ❒ Repair ❒ Replace ❒ Weatherstrip ❒ Screen

Other ______________________________________

Windows ❒ Repair ❒ Replace ❒ Weatherstrip ❒ Screen

Other ______________________________________

❒ Repair roof

❒ Move compost into rodent proof container

❒ Fix leaking irrigation

❒ Eliminate standing water

❒ Improve drainage

❒ Screen drains

❒ Bring order to storage sheds/garages

❒ Store rodent nesting material (fabric, paper, rug scraps, plastic, insulation) in rodent-proof containers

❒ Store grass seed and pet food in rodent-proof containers

❒ Remove debris, lumber or rock piles

❒ Move firewood piles as far away as possible from structure

❒ Cut grass or weeds

❒ Remove fallen fruit or nuts

❒ Remove fecal matter (rodents, bats, birds)

❒ Sanitize animal droppings

❒ Investigate secondary pest potential from rodent infestation (e.g. fleas, mites)

Floor Plan

Building location ____

Draw a floor plan and mark locations for repairs or pest-proofing.

Landscape Monitoring

Date 6/15

Name of Person Monitoring John Doe

Describe location of appropriate category:

Ornamental beds ______ Fence Lines ______

Sport turf ______ Paved Areas ______

Ornamental turf ______ Trees Northwest corner of school entrance

Playground ______ Other ______

Name of Plant	Condition* of Plant (Excellent Fair Good Poor)	Name of Pest (if any are present)	Abundance* of Pests (Few Common)	Abundance* of Plant Damage (Abundant Innumerable)	Presence of Natural Enemies	Management Activities	Comments
Blue Spruce	Good	Cooley Spruce Gall Aphid	Common	Common	None	Pruned 80% of Galls out of tree	Continue monitoring
			EXAMPLE				

*See accompanying charts for explanation

Landscape Monitoring

Date ____________________

Name of Person Monitoring ____________________

Describe location of appropriate category:

Ornamental beds ____________________ Fence Lines ____________________

Sport turf ____________________ Paved Areas ____________________

Ornamental turf ____________________ Trees ____________________

Playground ____________________ Other ____________________

Name of Plant	Condition* of Plant Excellent Fair Good Poor	Name of Pest (if any are present)	Abundance* of Pests Plant Damage Few Common Abundant Innumerable	Presence of Natural Enemies	Management Activities	Comments

*See accompanying charts for explanation

Indicators of Plant Condition

Plant Condition Rating	Leaf Color	Amount/Size of Growth	Damaged Plant Parts	Presence of Pest Problems
Excellent	Good	Adequate	None to few	No major ones
Good	Good	Slightly reduced	Few to Common	A few minor ones
Fair	Poor	Much reduced	Common to abundant	Either major or minor ones occurring frequently
Poor	Poor	Severely reduced	Innumerable	Both major and minor ones occurring frequently

Leaf Color: Note that there are healthy plants that do not have bright green leaves. Leaves can be purple, yellow, or sometimes a mottled yellow and green (variegated). Good leaf color will not always be the same; it will depend on the kind of plant.

Amount/Size of Growth: This refers to the length of the new growth for the season as well as the number of new leaves, and the size of the leaves, flowers, or fruit.

Damaged Plant Parts: Look at the whole plant. Are there leaves with holes, spots, or discolorations? Are there wilted or dead leaves? Are there dead twigs or branches? Is the damage only on old leaves while new leaves look perfectly healthy?

Presence of Pest Problems: A major pest problem is one that has seriously affected or injured the plant and requires management. A minor pest problem may or may not have affected or injured the plant and may or may not require management.

Pest and Plant Damage Abundance Chart

Abundance Rating	Indicators of Abundance
Few	Organisms or plant damage occasionally found, but only after much searching.
Common	Organisms or plant damage easily found during typical searching.
Abundant	Organisms or plant damage found in large numbers – obvious without searching.
Innumerable	Organisms or plant damage extremely numerous – obvious without searching.

These charts were adapted from Michigan State University *Pest Management Manual*

Weed Monitoring Form for Turf

Location of Turf ____________________ Date ____________________

Data Collected By ____________________ Length of Pace ____________________

Distance between sampling points of transect ______________ (for example every nine paces)

Number of transects ____________________ Length of transects ____________________

Sketch of location of transects

	Transect A					Transect B					Transect C			
	Yes	No	Bare	Weed I.D.		Yes	No	Bare	Weed I.D.		Yes	No	Bare	Weed I.D.
1					1					1				
2					2					2				
3					3					3				
4					4					4				
5					5					5				
6					6					6				
7					7					7				
8					8					8				
9					9					9				
10					10					10				
11					11					11				
12					12					12				
13					13					13				
14					14					14				
15					15					15				
16					16					16				
17					17					17				
18					18					18				
19					19					19				
20					20					20				

Average % weed growth ____________________ Average % bare area ____________________

Total the number of boxes marked 'Yes' in each column. Multiply this number by 100 and divide by 60 [the total number of samples taken). The result is the average percentage of weeds growing in the turf area. Follow the same procedure to calculate percentage of bare area.

Roach Trap Monitoring

Building # 3

Room or Area Cafeteria

Name of Person Monitoring John Doe

Trap #	Room # or Name	Date Trap was Set	Date Trap was Read	Trap Missing	Location Description	Roaches Adults	Roaches Nymphs	Roaches Total
1	Kitchen	3/5	3/26		SE Drain, under gate	0	0	0
2	Kitchen	“	“		S Sink under electric box	1	1	2
3	Dishroom	“	“	yes	S under conveyor belt	-	-	-
4	Dishroom	“	“		N under conveyor belt	0	0	0
5	Storage	“	“		left side of door	0	0	0
6	Dining	“	“		W serving counter	0	2	2

EXAMPLE

6 Total # of Traps

0.66 Average # of Roaches/Traps
(Total # of Roaches divided by total # of traps)

Total # of Roaches 4

*See accompanying charts for explanation

Roach Trap Monitoring

Building # ________

Room or Area ________ Name of Person Monitoring ________

Trap #	Room # or Name	Date Trap was Set	Date Trap was Read	Trap Missing	Location Description	Roaches Adults	Roaches Nymphs	Roaches Total

________ Total # of Traps

________ Average # of Roaches/Traps

(Total # of Roaches divided by total # of traps)

Total # of Roaches ________

*See accompanying charts for explanation

Pest Control Trouble Call Log

____

TROUBLE CALLS						PEST MANAGEMENT RESPONSE		
Date	Building	Problem Description	Reported by	School Contact	Phone	PCO Name	Action Taken	Materials* Used & Amounts Used

*Pesticides, caulk, traps, etc.

Pest Inspection/Sanitation Report

Date ______________________ Time In __________ Out __________

Building#/Location ____

Inspector ____

Inspection Type ❒ Initial ❒ Quality Control ❒ Routine

Evidence of Infestation(s)

Pest	Location(s)	Pest	Location(s)
Ants		Fleas	
Cockroaches		Stored Prod. Pests	
Mice		Pigeons	
Rats		Other	

Sanitation Survey

Food Preparation	Yes	No	Receiving	Yes	No
Equipment clean			Floors clean		
Appliance drip pans clean			Clutter		
Floors clean			Empty boxes stored in cold storage		
Floor drains clean			Empty boxes stored away from kitchen		
Sink drains clean			Student and Staff Areas		
Counters/Tables clean			Restrooms clean		
Food stored in pest-proof containers			Plumbing leaks		
Perishables stored in refrigerator			Locker room clean		
Garbage removed daily before closing			Food stored in locker room		
Spillage cleaned regularly			Teacher's lounge clean		
Standing water			Food stored properly in lounge		
Plumbing leaks			Food stored in student, staff, or teacher desks		
Windows/Door screened			Trash removed daily before closing		
Gaps around/under doors or windows			Janitorial closet clean		
Pest proofing needed			Pest Proofing needed		
Storage Areas			Exterior		
Floors clean			Dumpster/garbage cans cleaned weekly		
Floor drains clean			Dumpster/garbage cans have lids		
Food stored in pest-proof containers			Lids closed on dumpster/garbage cans		
Recyclables cleaned before storing			Garbage area downwind from kitchen		
Spillage cleaned regularly			Dumpster/Garbage area clean		
Items stored 6" to 8" off floor			Garbage removed at least weekly		
Items stored 12" to 18" away from wall			Pet waste removed daily		
Stock rotated			Loading dock clean		
Clutter			Gaps under/around doors		
Pest proofing needed			Area is trash- and weed-free		
Other			Standing water		
			Pest proofing needed		
			Outside eating area cleaned daily		
			Other		

Comments/Recommendations ____

____

APPENDIX N

Inspection Checklist for Detecting Structural Decay and Structural Damage

Check the following locations for structural decay and pest damage. Check both visually and by probing with a pointed tool, such as an ice pick. Look for signs of moisture, damaged wood, insect frass, and termite earthen tunnels and/or fecal pellets.

Roof, Overhangs, Gutters, Eaves, Trim, Attic

Roof Surface

Check the roof for cracks, missing shingles, and other openings where moisture might enter. Shingles should extend 3/4 inch or more beyond the edge of the roof and should form a continuous drip line at the eave and end rafters, or at the rake boards that cover the end rafters.

Remove leaves from the roof surface, and replace any missing shingles. Install flashing or an aluminum drip edge under the first course of shingles to divert rainwater from the fascia board and walls of the building.

Be careful not to block eave vents. Install flashing; it should curl over the forward edge of the fascia board about 2 inches and then run about 6 inches beyond a vertical line drawn from the inside face of the wall studs.

Check for the formation of masses of ice on the roof near the gutters, which can lead to water filtration and/or excessive condensation on interior attic walls.

Gutters

Check for poorly sloped, clogged, rotted, or leaking gutters that can lead to eave, overhang, or siding leaks and rots. Remove leaves and twigs that absorb moisture and cause rot. Flush gutters with a hose prior to the rainy season. Install downspout leaf strainers and gutter guards.

Attics

Extra effort is needed to inspect areas difficult to see or reach. Use a good light source and a probe. Search for rain seepage or decay around vent pipes, antennas, wall top plates, skylights, and other vents.

Eaves, Overhangs, and Fascia Boards

Make sure there is at least 18 inches of overhang to allow proper water runoff. Extend short overhangs. Search for soft, tunneled, cracked, or exposed areas. Check areas where algae, moss, lichens, or discoloration occurs; these symptoms may indicate moisture problems and termites.

Flashings

Make sure areas around vents, chimneys, and dormers are flush and well sealed. Rusty or broken nails can cause problems in flashings. Aluminum or galvanized nails are required to prevent electrolysis (a chemical reaction between dissimilar metals that causes the nails to disintegrate). Seal nail head and flashing joints with marine-quality caulk or silicone (tar preparations are cheapest, but they crack after a few years in the sun).

Damaged or discolored areas

Search for exposed areas that are soft, tunneled, cracked, rotted, or blistered. Check for algae, moss, lichens, or discoloration, since these areas indicate potential openings for fungi and/or insects. Locate the sources of moisture and make the necessary repairs.

Outside Walls

Rusty Nails

Check for rusty nails or nail staining, which indicates moisture within the wall and/or the use of non-galvanized nails. Replace nails with aluminum or galvanized nails or screws.

Deteriorating Paint

Look for signs of deteriorating paint such as loss of paint sheen and bubbling and peeling; scrape and sand the surface and repaint. If the wood seems soft, weak, or spongy, scrape out the spongy parts. If holes are smaller than 1/2 inch in diameter, fill them with caulk. Larger holes can be filled with epoxy wood-filler. If holes are very large, replace the wood.

Building Siding That is Stained or Buckled

Stained or buckled siding (with or without peeling paint) is a symptom of underlying moisture, rot, or insects. Check for moisture caused by splashing rain or lawn sprinklers. If possible, remove the source of the moisture and refinish or replace the damaged wood. Consider using a more durable material, such as aluminum siding. Pressure-treated woods are treated with toxic materials and their use should be minimized.

Damaged Wood Junctions

Moisture and insect problems often occur where wood pieces join or abut, particularly when there is shrinkage, splintering, or settling. Corners, edges of walls, roof-siding intersections, and siding-chimney contacts are particularly vulnerable. Apply water repellent and caulk to these joints, and monitor them regularly for building movement.

Weathering of Exposed Lumber/Beam Ends

Check for expanded, split, or cracked lumber ends, which provide access for moisture and insects. Even previously treated wood is subject to attack if the openings are deep enough. Caulk cracks and monitor for further developments.

Loose Stucco or Cracks in Stucco

Search for cracks, especially stress cracks around windows and doors. These conditions can provide access to moisture, termites, and decay organisms. Caulk cracks. If they are large, consider replacing the old stucco.

Moisture Accumulation around Laundry Facilities, Especially Dryer Vents

Check for signs of moisture accumulation around the vent. Modify the vent to direct exhaust air away from the building.

Moisture Associated with Pipes and Ducts

Check for moisture where ducts pass through wooden parts of a building. Also, check downspouts during heavy rains for leakage and proper drainage. Insulate ducts, install splashguards below downspouts, repair the spouts, and direct water away from buildings.

Moist Window Sills, Windows, or Doors

Check for cracked sills and casings, and poorly fitted windows and doors. Badly fitted doors may indicate warping of the door or its casing from excessive moisture or uneven house settling. Moisture problems can alter door jambs. Warped and cracked sills and poorly fitted windows and doors allow water access which aids decay and provides initial insect habitat.

Caulk cracks and monitor for further development. Warped door thresholds and jambs may need replacement, and casings may need repair if the cracks are too large to caulk effectively.

Foundation and Grade

Soil Surface

Make sure the soil surface slopes away from the school building in order to carry water away from the foundation. Seepage under the foundation will cause it to crack and settle. Add fill to direct the water away from the house but make sure there is at least 8 inches between the top of the fill and the sill. If clearance is small, consider installing foundation "gutters". Install splash blocks and perforated pipe. Check their performance during rains or test the system with a hose. A sump pump can also be used to move water away from the foundation.

Low Foundation Walls and Footings Allowing Wood-to-Soil Contacts

Check for wood in contact with the soil. Wood should be at least 8 inches, and preferably more, above the soil surface. Low foundation walls or footings often permit wooden structural members to be exposed to the soil, providing access for subterranean termites. Repair these areas or install subgrade concrete "gutters" where the house sills sit too close to ground level. Remove wood that is exposed to the soil and replace it with concrete.

Foundation Cracks

Check for cracks that allow decay organisms access to wood. Cracking may also indicate uneven house settling. Monitor cracked walls for discoloration and seepage during rains. Termites use cracks to gain access to wood hidden from view. If the problem is serious, the foundation may need repair.

Brick Veneer or Stucco Applied to the Foundation

Check the bond between the veneer or stucco and the foundation wall. If it is failing, moisture and termites may have a hidden entrance to wooden portions of the building. Remove the loose covering and explore the extent of the decay.

Crawl Space, Basement, and Foundation

Make sure enclosed crawl spaces are vented to allow moist air to escape. Milder climates are especially vulnerable to dry-rot fungus. In humid climates, the subfloor can be wet from condensation from interior air-conditioning. Shrubbery or other obstacles that block airflow through foundation vents cause air underneath the house to stay warm and moist-an ideal environment for termites.

Clean existing vents of dust, plants, and debris. Foundation vent openings should equal 2 ft2 of opening for each 25 linear feet of outside wall. An opening should occur within 5 feet of each corner. Add more vents if needed. The top edge of the concrete under all vents should be at least 6 inches above the finished grade to allow sufficient ventilation. Vents located below grade may require wells to prevent surface water from entering subfloor and basement areas. Divert roof drainage away from vents.

Corners of the Building

Check for moisture accumulation and stains at junctions of wood surfaces in these areas. Install additional cellar or crawl space vents.

Enclosed Areas

Check for proper ventilation under staircases, porches, and other enclosed areas, since these are vulnerable to moisture accumulation. Look for decayed, discolored, or stained areas. Adjust or add venting.

Vapor Barriers

Check for condensation on the subfloor and/or sill, which may indicate the need for vapor barriers on the subfloor and on the soil surface in the crawl space. Such barriers can be installed to reduce the moisture resulting from poor soil grading, unexpected seepage, or high rainfall.

Cover the crawl space soil surface with a 6-mil polyethylene vapor barrier. Use polyethylene, not roofing paper, which can rot. A slurry of concrete can be placed over the plastic to protect it from rodents. Where condensation continues, consider installing extra vents or electric-powered vents whose fans and openings are operated automatically. A sump pump can be installed to remove standing water.

Wood-to-Stone or Wood-to-Concrete Contacts

Check to see whether the wood is pressure-treated (look for perforation marks from the chemical injection on the surface of the wood). Replace untreated wood with rot-resistant or pressure-treated wood. Be sure sealing material is used between the wood and stone or concrete, and place a metal washer between posts and footings.

Leaky Pipes or Faucets

Even small leaks keep the wood or soil underneath continuously moist, thereby setting up ideal conditions for termites. Areas where rain splashes on walls should be protected with rain guards. Do not allow sprinklers to spray the side of the building. Fix all leaks, and change irrigation practices where necessary.

Water- or Space-Heating Units

Check to see whether the heating unit is insulated. If the soil near the flame is kept warm throughout the year due to lack of insulation, microbial and insect development will be accelerated. Insulate the heater and cover the soil with concrete.

Paper Collars around Pipes

Since paper is almost pure cellulose, it is extremely attractive to termites and should be removed and replaced with other insulting materials not capable of being eaten by termites.

Miscellaneous Openings

Meter boxes, bathroom inspection doors, pet doors or openings, milk delivery doors, and air exhaust vents should be checked for water access, cracks, termite pellets, and soft areas.

External Areas

Porches

Check for wooden steps touching the soil, and inspect for possible decay or termite access. The porch surface must slope away from the building to carry rain away quickly. If the porch does not slope away from the building, check siding for moisture and termites. Tongue-and-groove flooring is a water trap. If there is a space between the porch and the building, check for drainage problems.

Caulk and repair cracks. Fill spaces between tongue-and-groove floorboards with caulk or resurface and refinish with wood-sealing compounds and appropriate paint. Another floor can be placed over the first.

Earth-Filled Porches

Soil should be at least 8 inches, (optimally 12 to 18 inches) below the level of any wooden members. Remove the excess soil where possible, regrade to enhance drainage and redesign the porch to eliminate earth/wood contact.

Planter Boxes

Check planter boxes that are built against the building. If they are in direct contact with the building, they allow direct termite access to unprotected veneer, siding, or cracked stucco. One remedy is adding 2 to 3 inches of protective concrete wall between the planter and the building. An air space several inches wide must separate the planter wall from the building and must be kept free of dirt or other debris.

Trellises and Fences

Check for wooden portions of the trellis that touch the soil and are connected to the house, since they provide a direct link to the house for wood-rot and termites. Check fence stringers and posts for decay. Cut off the decay and install a concrete footing for trellises and fence posts. Replace decayed stringers and leave a small gap between the stringers to allow air circulation. Separate wood and concrete with metal washers.

Wooden Forms around Drains

These are sometimes left in place after the concrete foundation is poured and provide termites with access routes to inner walls. Areas and joints around pipes rising from slabs should be sealed with tar or other adhesive to prevent water and termite access. Caulk the holes and monitor them for decay and excess moisture.

Gate Posts, Fence Tie-ins, Abutments and Columns

Inspect these for weakness and rot especially around areas adjacent to the soil. Exposed areas can provide cracks for termite invasion. If wooden posts go through concrete into the soil below, check the posts for evidence of termite attack. The bottoms of these posts should be cut and replaced with a concrete footing. Cut post tops at an angle to promote runoff and prevent water from penetrating the vulnerable end grain.

Balconies and Landings

Surfaces should be sloped away from the building. Check junction of floor and siding for moisture and insects.

Wood Debris under and around Buildings

Pieces of wood, particularly partially buried tree roots or construction lumber, can help support a termite colony until the population grows large enough to attack the house itself. Since cardboard boxes are very attractive to termites, they should be removed from crawl spaces or basements with earthen floors.

Interior Locations

Areas with water stains or mold growth indicate excessive moisture and should be analyzed for corrective action. Pay special attention to areas listed below.

Kitchen Pipes

Look for condensation and leaks, especially where pipes enter walls. Repair leaks and insulate pipes where condensation is excessive.

Counter Areas

Check around and below sink surfaces for moisture and decay. Caulk or otherwise protect wall surfaces from moisture. Subsurface areas damaged by water leaking from above may be tolerated if the surface leaks are repaired.

Exhaust Vents

Check for moisture leaks from outside. Repair with caulk or water-resistant sealing material, or replace the vent and the rotted wood around it. Use extra flashing to fill the gap.

Toilets

Check the integrity of the floor around each toilet base by thumping lightly with a hammer. Check the wax seal for leakage at the floor/toilet pedestal intersection. Check the cellar or crawl space beneath the toilets to see whether the leakage has caused damage. Replace the wax seal if necessary and repair the surrounding water damage.

Showers and Sinks

Check all sinks and showers for a sound caulk seal. Look for splash over on the floors from inadequate water barriers or user carelessness. If moisture is visible from crawl spaces, it may indicate a crack in the floor or in drainage pipes. If moisture is visible in the ceiling, it may indicate cracks in the delivery pipes.

Repair or replace flooring materials, pipes, drains, or sink basins if necessary. Sealing compounds may be useful when leaks are relatively recent and small, especially if termites have not been found; however, regular monitoring is necessary if sealing materials are used.

Tile Walls

Check for mildew stains. Make sure the grout in tile walls has a silicone coating to prevent water penetration. Clean the walls regularly to remove mildew and improve ventilation.

Ceilings

Check for blistered areas, since these can indicate moisture leaks in the area above or inadequate installation of a vapor barrier. Repair leaks and faulty vapor barriers.

Windows

Check for moisture accumulation and/or water stains on window frames and walls. Search for evidence of decay or insect attack next to glass areas where condensation accumulates, at edges where moldings meet walls and casings, and in window channels and door jams. Gaps between window and door casings may be avenues for hidden moisture and insect access. Check interior walls beneath windows, especially if they are regularly wetted by garden sprinklers.

Open windows when feasible to improve air circulation. Install double- or triple-glazed windows when replacement is necessary. Use aluminum frames if wooden frames are decaying. Adjust or move sprinklers so water does not hit windows.

Closets

Check coat and storage closets for dampness. A light bulb left burning continuously in a damp closet will often generate enough heat to dry it out, but make sure the bulb is far enough away from stored materials to avoid creating a fire hazard. Containers of highly absorbent silica gel, activated alumina, or calcium chloride also remove moisture from the air in enclosed spaces. These agents should be placed out-of-reach to avoid accidental exposures. Avoid use of silica gel where children may tamper with the containers. These chemicals can be reused after drying them in the oven. Small exhaust fans can also improve closet ventilation.

Floors

Sagging or buckling floors can indicate shrinkage or rot from excessive condensation or water leaks. Gaps between floor and baseboards can indicate wood damage from insects, fungi, or water-triggered swelling and shrinkage.

APPENDIX O

Training and Licensing Opportunities

A variety of pest management licensing and training opportunities exist in California. The following organizations can provide information about licensing and/or training:

- The Department of Pesticide Regulation regulates pesticide use and sales and fosters reduced-risk pest management. For information about any of DPR's programs phone 916-324-4100 or see the Web site at www.cdpr.ca.gov.
  - Licensing: DPR is responsible for examining and licensing qualified pesticide applicators, and for certifying pesticide applicators who use or supervise the use of restricted use pesticides. See the Licensing and Certification Program Web page at www.cdpr.ca.gov. DPR's licenses focus primarily on agricultural uses although maintenance gardeners are licensed by DPR.
  - Training: DPR has a list of all approved continuing education classes on the Web site that are frequently updated. Go to www.cdpr.ca.gov and click on either the Licensing and Certification Program link or the School IPM page link.
- The Structural Pest Control Board licenses businesses and individuals to perform control of structural pests. They also offer training. Contact them at 916-561-8700 or online at http://www.pestboard.ca.gov/index.html.
- Local community colleges: See the local yellow pages or go to http://www.cccco.edu/ for more information.
- California State University: Visit the Extended University homepage at http://www.gateway.calstate.edu/extension/index.shtml for details.
- UC IPM's Pesticide Safety Education Program. This develops, tests, evaluates, and disseminates pesticide safety education models and materials in order to promote the safest and most effective use of pesticides. See http://www.ipm.ucdavis.edu/GENERAL/pesticides.html for details and up-to-date class listings or call (530) 752-5273.
- UC Extension: Each campus of the University of California offers continuing education courses. Go to http://www.ucop.edu/unex/ for more information.
- Many professional associations include IPM training at annual meetings or hold separate IPM training sessions.

For more information about local IPM training, contact the County Office of Agriculture or the county office of the University of California Cooperative Extension.

APPENDIX P

Pesticide Safety Information Series N

N-1 SAFETY REQUIREMENTS FOR PESTICIDE HANDLERS In NonCrop Settings

This leaflet explains pesticide safety guidelines and requirements for: employees handling pesticides in industrial/institutional settings and employees of structural pest control operators, landscape and maintenance firms, rights-of-way maintenance companies, and similar businesses. The following information will help build the framework for a safe working environment. The term "handle" refers to any activity related to the application of pesticides

Hazards of Pesticides:

Before a pesticide is sold, many tests are conducted to determine the possible health and environmental hazards. Pesticides (and other chemicals) can be absorbed through your skin and into your body to cause illness. Hand exposure contributes significantly to the overall hazard of handling pesticides. Protection of the skin is often the most difficult problem associated with pesticide use.

Labeling and Regulations:

Federal laws require specific precautions to be on pesticide labels to protect your health. In addition, every label must display a signal word that gives an indication of the relative acute health hazard. The signal words are:

- "Danger" indicates the pesticide is extremely toxic
- "Warning" indicates moderate toxicity
- "Caution" indicates low toxicity.

Federal and State laws require that pesticides be used according to the requirements on the label. Additionally, the State establishes its own regulations. In some cases, State regulations are more strict than Federal laws; they protect you in some use conditions specific to California. Follow both pesticide labels and State regulations. In case of a conflict, follow the more strict requirement.

Exemptions: When medical sterilants, pool and spa chemicals or antimicrobial agents used as sanitizers or disinfectants are handled, the employer is exempt from complying with provisions of the worker safety regulations (Title 3, subchapter 3) provided any applicable provisions of Title 8 (Cal/OSHA regulations) are followed. You must still follow the requirements on the pesticide label.

Interpretation of Label Safety Precautions:

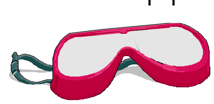
Interpret the safety precautions on the label carefully. Take into account the signal word and the application situation. If the label says to avoid breathing spray mist, a respirator should be worn to protect you from inhalation hazards. Hazardous conditions may occur indoors where there is little or no air movement. In addition, people in the same building (but not in the treated area) may be exposed because the ventilation system carries the pesticides or vapors around the building. Assess the whole situation prior to handling pesticides.

Use of engineering controls, such as closed systems and water soluble packaging, are always preferred over the use of personal protective equipment (PPE), such as a respirator, rainsuit, etc. In some situations, if engineering controls are used, handlers can wear less PPE. Substitutions allowed when engineering controls are used are found in Pesticide Safety Information Series (PSIS) N-3, Table 1.

Hand pouring and moving (transporting) pesticide concentrates presents the greatest hazard to the people involved. After a pesticide is mixed and loaded into the application equipment to be applied as a dilute liquid spray, the hazards decrease a little. However, even when using the dilute solution, the applicator should always try to avoid getting wet with the spray regardless of the signal word on the label.

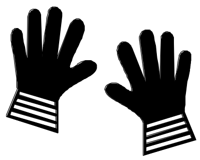
Specific Safety Precautions to Follow in California:

- Eye protection is required for most activities involving mixing/loading, application and equipment maintenance. Some exemptions exist for some application of vertebrate baits or solid fumigants and applying non-insecticidal lures.

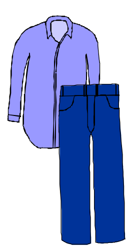


- Protective eyewear can be safety glasses (with brow and temple protection), a face shield, goggles, or full face mask (part of respiratory protection). Regular eyeglasses and sunglasses DO NOT provide adequate protection.

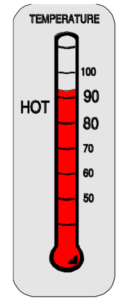
- Employees involved in the mixing and loading of pesticides, pesticide equipment maintenance and hand application (including hand-held equipment) of pesticides must be provided with and use gloves.



- Your employer must provide clean or new gloves each day.
- If the type of glove needed is not on the label, you must use gloves made of rubber, neoprene or other chemical-resistant material.
- If the label specifically states that the handler should not use gloves, they must not be worn.
- Wear respiratory protection when using pesticides that are toxic when inhaled, such as fumigants, powders, dusts, or some liquids.
- The type of respiratory protection required will be on the pesticide label.
- Some medical conditions, such as heart and lung disease, may prevent you from using respiratory protection. If you have these conditions, a physician must examine you prior to using respirators.
- Your employer must have a written procedure for selecting, fitting, cleaning, sanitizing and maintaining respiratory equipment. See PSIS N-5 for additional information on respiratory protection.
- If you handle pesticides with the signal word ‘DANGER” or ‘WARNING” on the label, your employer must provide you with clean coveralls (a one- or two-piece garment with long-sleeves and long pants) every day these pesticides are used. (This does not apply to those who handle fumigants, unless the label specifically requires use of coveralls.)



- If the pesticide label or California regulations require the use of chemical resistant protection, your employer must provide a clean chemical-resistant suit, apron (if specified), footwear and headgear, that covers the body, feet and head.
- Due to the high temperatures that often exist in California, heat stress from use of chemical resistant clothing may be a greater hazard than pesticide exposure. In the absence of engineering controls applications should be made at night or during the cooler portions of the day when protective equipment can be tolerated.
- If required to use a chemical resistant suit, you <u>must not</u> work in temperatures above 80°F in daylight hours or above 85° during nighttime hours, unless wearing a cooled suit. Some exemptions from the chemical resistant clothing requirements exist for handlers (see PSIS N-3, Table 1).



- Your employer must provide a place to change clothes and wash at the end of the workday if you handle pesticides with the signal word "Danger" or "Warning".

Training

California regulations require you to be adequately trained before you handle pesticides. Your employer must have a written training program for employees who handle pesticides. The training must include for each pesticide or chemical group of pesticides:

- the meaning of precautionary statements on the pesticide label;
- information on the immediate and long-term hazards of the pesticides to be used;
- routes pesticides can enter the body;
- signs and symptoms of poisoning;
- emergency first aid;
- how to obtain emergency medical care;
- routine and emergency decontamination procedures;
- need for, limitations, use and cleaning of PPE;
- prevention, symptoms and first aid for heat-related illness;
- safety requirements and procedures;
- environmental concerns;
- instructions not to take pesticides or pesticide containers home;
- applicable regulations, Material Safety Data Sheets (MSDS), and PSIS leaflets;
- location of the written Hazard Communication information (PSIS N-8); and
- your rights as an employee.

This leaflet assists readers in understanding pesticide regulations. It is not a legal document. The legal reference can be found in the California Code of Regulations, Title 3. The words "must" and "should" used in the text are not the same. The word "must" means the action is required and comes from California regulations. The word "should" means additional handling practices that are recommended to further reduce exposure.

Pesticide Safety Information

Worker Health and Safety Branch

Series N

N-2 STORAGE, TRANSPORTATION AND DISPOSAL In Noncrop Settings

General Information:

This leaflet describes general methods and requirements for proper storage, transportation, and disposal of pesticides and containers. The following simple precautions will drastically reduce the number of accidental pesticide poisonings, especially those involving children.

- Keep pesticides in their original containers.
- Never put pesticides in containers used for food, drink, or household products.
- DO NOT take home or use around your home any pesticide you use at work.

Storage:

Properly store or keep pesticides and empty containers under direct personal control at all times. Direct personal control means a responsible person who can prevent contact by unauthorized persons. A responsible person must have the pesticide(s) in sight, if under direct personal control and adjacent to a road or populated area. Acceptable pesticide storage includes:

- a locked, fenced area
- a lockable storage compartment
- a locked truck or trailer with side racks (the tops of the racks should be a minimum of six feet above the ground).

Keep storage areas clean, dry, ventilated and adequately lighted. Read and follow storage requirements explained on the label. If pesticides are stored with fertilizers, keep the two separated. Pesticides and fertilizers might react chemically and result in a fire. Do not store pesticides near food, animal feed or personal protective equipment because of possible contamination.

Your employer may need a hazardous waste facility permit, if he/she stores pesticide waste, such as old products or unrinsed containers. For more information about specific requirements, contact the California Environmental Protection Agency (Cal/EPA), Department of Toxic Substances Control. The telephone number can be found in the Government Pages of your telephone book.

Storage Posting Requirements. Post warning signs on all storage areas containing pesticides (or empty containers) with the signal words "DANGER" or "WARNING" on the label. Post signs on all directions of possible approach. You must be able to read the sign from 25 feet away. These signs must state:

DANGER
POISON STORAGE AREA
ALL UNAUTHORIZED PERSONS KEEP OUT
KEEP DOOR LOCKED WHEN NOT IN USE

Transportation:

To transport pesticides safely you must follow these simple procedures:

- Do not transport pesticides in the same compartment with a person, food, or animal feed.
- Transport pesticides in a secure upright position.
- Tightly close containers to prevent spillage.
- All containers must be labeled.
- This labeling must be the original product labeling or service container labeling.
- Service container labeling requires the name and address of the person responsible for the container, the common name of the pesticide and the signal word from the original label.

There may be other regulations to follow when transporting hazardous materials. As a general rule, consult the California Highway Patrol, Motor Carrier Safety Unit when transporting more pesticides than you will use in a few days. Their telephone number can be found in the Government Pages of your telephone book.

Rinsing:

All containers under 28 gallons, must be rinsed at the time of use, unless they are returned to the registrant or the pesticide is not diluted during use. There are two rinsing procedures. Follow one of them to ensure you have properly rinsed containers.

Procedure #1:

1. For containers smaller than 5 gallons, use enough water to fill the container ¼ full. For larger containers, use enough water to fill it one-fifth full.
2. Put the appropriate amount of water into the container. Close the container securely and agitate.
3. Drain the solution into the mix tank. Allow the container to empty completely.
4. Repeat steps 1 - 3 a minimum of 2 more times.

Procedure #2:

1. Turn the empty container over and place the opening over a nozzle. This nozzle must be located in the opening of the mix tank so the liquid will drain into the tank. The nozzle must be able to rinse all inner surfaces of the container.
2. Turn the nozzle on and rinse until the water coming from the container is clear. Use a minimum of ½ the container volume of water.

You may use other rinsing procedures, if they have been approved by the Department of Pesticide Regulation.

Disposal:

Dispose of all empty pesticide containers in a manner approved by the Cal/EPA, Department of Toxic Substances Control. Take all glass, plastic, or metal containers to an approved disposal site. DO NOT BURY ANY PESTICIDE CONTAINER.

For information on local requirements, contact the local agricultural commissioner. In many counties, people must possess a permit or certificate issued by the commissioner to dispose of rinsed containers.

Exemptions:

The above procedures are not required for sanitizers, disinfectants, medical sterilants or pool or spa chemicals.

This leaflet assists readers in understanding pesticide regulations. It is not a legal document. The legal reference is in the California Code of Regulations, Title 3. The words "must" and "should" used in the text are not the same. The word "must" means the action is required and comes from California regulations. The word "should" means additional handling practices that are recommended to further reduce exposure.

N-3 ENGINEERING CONTROLS (Closed Systems, Enclosed Cabs, Water Soluble Packaging) In Noncrop Settings

General Information:

Engineering controls are methods used to reduce exposure (closed system, enclosed cabs, water soluble packaging, etc.) other than personal protective equipment (respirators, gloves, etc.). Engineering controls are preferred over personal protective equipment (PPE) for reducing exposure. Hand-pouring highly toxic pesticides is a very hazardous activity, and has resulted in many serious human illnesses and injuries. Many more pesticide-related illnesses and injuries resulted from unprotected persons applying toxic pesticides. Proper use of engineering controls reduces the potential for human exposure. On the other hand, improper use, cleaning or maintenance of these systems can also lead to excess exposure. In many instances, substitution of PPE required by label or California regulation is allowed when properly using some engineering controls (see Table 1).

Closed Systems:

The closed system requirement applies primarily to use of pesticides in agricultural settings. However, handlers must use a closed system to mix and load minimal exposure pesticides (MEP), regardless of the intended use. Even if not required, proper use of a closed system can reduce mixer/loader exposure.

A "closed system" is a procedure for removing a pesticide from its original container, rinsing the emptied container, and transferring the pesticide and rinse solution through connecting hoses, pipes and couplings that are sufficiently tight to prevent exposure of any person to the pesticide or rinse solution. No rinsing is required when:

- the pesticide is used without dilution
- the container is a returnable or reusable container that will be sent back to the registrant

If you use a closed system, you must receive training on the proper use and necessary safety precautions during use.

You must wear PPE as required by the label or California regulations. Some substitutions for label-required PPE are allowed when using a closed system (Table 1). All PPE required by the pesticide label must be present at the work site for emergency use. Eye protection and gloves are still required in some instances when using a closed system (see Table 1 for exemptions).

California's Closed System Criteria: To meet California's requirements, a closed system must:

- remove the pesticide from the original container
- rinse the container
- transfer the pesticide to the mix tank
- be made of materials appropriate for use with pesticides and a pressurized system
- have gauges protected against breakage
- adequately measure the pesticide used
- have shut-off valves to prevent chemical from spilling when the hose is disconnected.

Do not remove the probe from the container unless the container is empty and rinsed, the pesticide was used undiluted and the container is empty or the probe has been approved for removal from partially empty containers. The system must have shut-off valves to prevent chemical from spilling when the hose is disconnected or removed. For more details on closed system criteria, contact the California Environmental Protection Agency, Department of Pesticide Regulation (DPR). You may obtain a list of closed systems that have been evaluated and found to meet these criteria from DPR ((916) 445-3920).

The system must be cleaned and maintained according to the manufacturer's instructions. If the system is not a commercially produced system, it must be maintained on a regular basis. A record of cleaning and maintenance must be kept.

Water Soluble Packaging:

Use of pesticides in water soluble packaging (WSP) is considered equivalent to mixing with a closed system. However, dilutions of MEPs in WSP must be transferred (i.e., from a mix tank to the application vehicle tank) via a closed system. DO NOT cut open WSP to use a partial package. This invalidates the closed system equivalency and puts you at risk of over exposure.

Enclosed Cabs:

Proper use of enclosed cabs reduce exposure of some applicators. An enclosed cab is a chemical resistant barrier that completely surrounds the occupant of the cab and prevents contact with pesticides or treated surfaces outside the cab. Enclosed cabs can include a closed cab on a spray rig or a truck or car with the windows and doors closed. There are two types of enclosed cabs:

- Cabs that have only the physical barriers (doors, windows, etc.) to prevent exposure
- Cabs acceptable for respiratory protection. The latter cab incorporates a dust/mist filtering and/or vapor/gas purification system in addition to the physical barrier. These cabs must meet certain criteria and be approved by the director of the DPR.

This leaflet assists readers in understanding pesticide regulations. It is not a legal document. The legal reference can be found in the California Code of Regulations, Title 3. The words "must" and "should" used in the text are not the same. The word "must" means the action is required and comes from California regulations. The word "should" means additional handling practices that are recommended to further reduce exposure.

Table 1: Allowed Substitutions for PPE When Using Engineering Controls

When using the following:	Handlers may substitute:*	For the following:
Closed system for pesticides with "Danger" or "Warning"	Coveralls, chemical resistant gloves and chemical resistant apron	PPE required on the pesticide labeling
Closed system for pesticides with "Caution"	Work clothing	PPE required on the pesticide labeling
Closed system under positive pressure	Protective eyewear**	
Mixing pesticides in water soluble packets	Use in water soluble packets***	Use of a closed mixing system
Enclosed cab	Work clothing and required respiratory protection	PPE required on the pesticide labeling
Enclosed cab acceptable for respiratory protection	Work clothing	PPE required on the pesticide labeling
Any pesticide	Chemical resistant suit	Coveralls and a chemical resistant apron

* For any substitution, all PPE required by the label must be available in case of an emergency

** When using a pressurized system, protective eyewear is required in addition to coveralls, chemical resistant gloves and apron for pesticides with "Danger" or "Warning" or in addition to work clothing for pesticides with "Caution" on the label

*** Using pesticides in water soluble packets is equivalent to mixing with a closed system. However, transfer from mix tank to application tank must be made with closed transfer equipment.

Pesticide Safety Information
Worker Health and Safety Branch
Series N

N-4 FIRST AID AND DECONTAMINATION

For Noncrop Settings

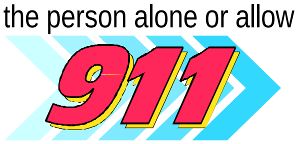
This leaflet provides basic first aid for employees who handle pesticides. The information supplements first aid statements found on pesticide labels. This leaflet **does not** meet the employer's requirement for emergency medical care nor for making prior arrangements for emergency medical care.

Illness While Working With Pesticides:

If you become ill while working with pesticides, stop work immediately. Notify your supervisor or a fellow employee than you are ill. Take the following steps to eliminate any source of continued pesticide exposure:

- Go to a source of fresh air.
- Remove work clothing.
- Shower completely, wash your hair, and change into clean clothing.
- DO NOT put contaminated clothing back on until they are properly washed
- If shower facilities are not immediately available, use the closest available clean water source to wash your body. This may be water from a shower, faucet or hose, or bottle.

In all cases: DON'T WAIT - DECONTAMINATE IMMEDIATELY. **Take** the ill or injured person to the nearest emergency medical care facility. Do not leave the person alone or allow them to drive.



If a person collapses while working with pesticides:

- immediately remove that person from the pesticide use area
- give the necessary resuscitation
- call 911 for emergency help, if a telephone is available
- warn emergency workers that the person may be contaminated with pesticides

REMEMBER: A sudden collapse may be due to a heart attack or other medical emergency not related to pesticide exposure.

All persons should receive cardiopulmonary resuscitation (CPR) training. The American Red Cross and the American Heart Association teach CPR. Contact the local chapter of either of these organizations to make arrangements for training individuals or groups.

It is very helpful and important to supply the physician or emergency room personnel with as much information as possible regarding the circumstances of exposure. Provide the physician with the name of the pesticide the victim was exposed to or handling. If possible, take a clean copy of the product label(s) to the physician with the victim. If a label cannot be taken in with the victim, write down the exact name of the product, EPA registration number and active ingredients and give it to the physician. As a last resort, take a clean, empty, labeled container or a sealed, labeled container to the physician along with the victim. (Exposure of emergency care or hospital personnel can occur if a container with pesticides is dropped and broken.)

Sudden Contamination With Pesticides:

Pesticides can be absorbed into the body by:

- breathing in dust or vapors
- skin or eye contact
- swallowing.

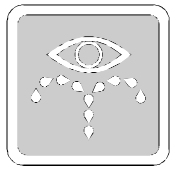
Breathing Dust or Vapors. In the event of a sudden, unexpected release of pesticide dust or vapor into the air:

- leave the area.
- if in an open area, go upwind at least 100 feet away from the dust or vapor.
- if indoors or in a confined area, leave the area immediately and go outdoors or to a well-ventilated area away from the dust or vapor.
- immediately move any person overcome by dust or vapors to an area away from the pesticides.

- proceed as described for persons who collapse while working with pesticides.

Pesticides In the Eyes.

- Immediately rinse the eyes with water.
- Hold the eyelids open and slowly pour water over the eyes.
- Never use a forceful stream of water directed into the eye as damage may occur. Use water flowing slowly and gently from a faucet or hose.



- Rinse the eye for at least 15 minutes.
- If symptoms of pain, discomfort, or visual problems are present after thoroughly rinsing the eyes, immediately take the affected person to the nearest emergency medical care facility.

Pesticides Spilled On the Clothing or Skin. Your skin is **not** an absolute barrier that prevents pesticides from getting into your body. Pesticides (and other chemicals) can be absorbed through your skin and into your body. Absorption of some chemicals is very rapid, while absorption of others is slow. It is important to remove any pesticide that comes into contact with the body whether on your skin or clothing. Many pesticides can eventually penetrate protective clothing, even if it is waterproof. All persons should remember the following procedures:

- Immediately remove all contaminated clothing.
- Wash all exposed skin areas with soap and water. If available, shower and wash your hair.
- Use any available clean source of water as discussed earlier.
- DO NOT WAIT -- DECONTAMINATE!
- Put on clean clothing.
- Properly wash contaminated clothing before wearing them again.
- If illness symptoms occur following a spill of pesticides onto the clothing or skin, immediately take the affected person to the nearest emergency medical care facility.

If the spill occurs indoors, warn other people in the area. Evacuate the area, if necessary. If the spill is small and materials are available, contain it with an absorbent, such as clay, saw dust or kitty litter. Do not attempt to clean any spill without proper protective equipment. Be sure to contact your supervisor or the person in charge of the building.

Pesticides Are Swallowed.

- The victim should drink sips of water or milk.
- Do **NOT** give fluids to an unconscious or semi-alert person.
- Call 911, a physician or the poison control center.
- **Check the pesticide label.**
- Some pesticide labels advise you **not** to make the person vomit. Vomiting after swallowing caustic chemicals may make the condition worse.

- Do **NOT** induce vomiting in an unconscious or semi-alert person.
- Immediately take such individuals to the nearest emergency medical care facility.
- To induce vomiting in an adult, give one ounce of syrup of ipecac, if immediately available. To induce vomiting in children, proportionately reduce the dose of ipecac syrup (2 to 4 teaspoonfuls). After giving syrup of ipecac, vomiting is usually delayed by 15 to 30 minutes.
- Do **NOT** administer salt water or mustard solutions to induce vomiting as may be recommended on some old pesticide labels. Salt and mustard solutions may be dangerous to use for this purpose.

REMEMBER: It is important to supply the physician or emergency room personnel with as much information as possible regarding the circumstances under which the victim became ill.

Additional Useful Information:

Your employer must post at the work site the telephone number, address and physical location of the facility where emergency care is available.

Many areas are served by regional poison control centers; you can contact any poison control center in California by calling 1-800-764-7661. Immediate contact with the regional poison control center will provide professional guidance on how to proceed with first aid and resuscitation measures.

N-5 RESPIRATORY PROTECTION
In Noncrop Settings

General Information:
This leaflet provides basic information to pesticide users on respiratory protection and helps you to comply with California's respiratory protection regulations (Title 3 California Code of Regulations section 6738).

Regulations require employers to have a written respiratory protection program at the work place. The program must cover selection, fitting, use, inspection, maintenance and cleaning of respirators. Adoption of the content of this Pesticide Safety Information Series (PSIS) leaflet meets the minimum requirements for the written program. Appendix 1 provides a sample written program.

Conditions Requiring Respiratory Protection:
Engineering controls are the best way to control airborne hazards. Examples of engineering controls are enclosure or confinement of the operation generating the hazard, ventilation to keep the airborne concentration below accepted levels, or substitution of less toxic materials. In some situations, the use of engineering controls, such as closed systems may exempt the worker from wearing respiratory protection (PSIS N-3 discusses these exemptions). Often, pesticide use creates a hazardous working environment. If hazardous pesticide concentrations cannot be controlled in other ways, you need to use personal respiratory protection. You may also need respiratory protection in emergency situations where the exposure is relatively brief.

Federal and state laws require pesticide labels to contain safety precautions. The label will include requirements for respiratory protection, if needed. If you are exposed to mist or spray, respiratory protection may be necessary when applying products with labels that only state "avoid spray." Always read and follow the safety information on the pesticide label.

Your employer must provide required personal respiratory equipment <u>and</u> you must use the equipment provided. The National Institute for Occupational Safety and Health must approve the respiratory equipment for that particular use.

Training:
You must receive training initially and annually in the need, use, sanitary care, and limitations of the respiratory equipment you may have to use.

Selection and Fitting of Respirators:
Proper respirator selection is critical. Pesticide labels are the primary source of information on the type of respiratory protection necessary. With this information, a safety equipment supplier will be able to provide the correct respiratory equipment. When exposed to pesticides that irritate the eyes, nose or throat, wear a full-face respirator to also protect your eyes. If using air-purifying respirators, NIOSH must approve the air-purifying element (filter or cartridge) for use against the specific hazard. For additional help in the selection process, consult one of the sources listed below.

Respirators come in different sizes to accommodate different sized faces. Every respirator wearer must receive training on fitting and testing respiratory equipment. When fitting a respirator, wear the respiratory equipment in normal, uncontaminated air to become accustomed to it. Then wear it in a test atmosphere.

Maintenance and Sanitation:

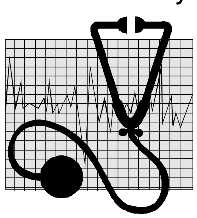
Your employer must repair or replace respiratory equipment as necessary due to wear and deterioration. A trained person should regularly clean and inspect frequently used respirators. Regular cleaning and inspection prolongs the useful life and assures the wearer that the respirator is working as efficiently as possible. For personal hygiene and communicable disease considerations, do not pass respirators from one individual to another without cleaning and sanitizing. Avoid this situation by assigning a respirator to each wearer.

When not in use, store respirators so the facepiece does not become deformed and is protected from excessive exposure to dust, sunlight, extreme temperatures, moisture or damaging chemicals. Any or all of the above will severely limit the useful life of the respirator. Plastic containers with lids can provide adequate storage for respirators.

Prior to use, inspect respirators maintained for emergency situations, such as canister gas masks and self-contained breathing apparatus (SCBA). If not used within a month, inspect and test this emergency equipment to assure reliable operation when needed. During an inspection, look to ensure cleanliness and that all components are present and operable.

Medical Evaluation:

Breathing through a respirator may require more effort than normal breathing. For some individuals, this effort is extremely difficult for various reasons. If required to wear a respirator, your employer must inform you that some medical limitations may interfere with use of respiratory protection. Some of those medical limitations include high blood pressure, heart disease, lung disease or a perforated ear drum. If you have such a condition, a physician must examine you to determine if you are physically able to perform assigned work while using respiratory equipment. The physician should determine what health and physical conditions are pertinent. Your employer must follow the physician's written recommendation concerning your capability to wear respiratory equipment. Your employer must keep written evidence on file that you were informed. A record of the physician's evaluation must be on file for each employee who indicates a possible medical limitation before that employee performs any work that requires respiratory protection.



Limitations of Respiratory Equipment:

Respirators have limitations. They cannot adequately protect a person from all contaminants under all conditions. The protection factor measures the protection provided to the wearer and indicates the efficiency of the respirator in reducing airborne contaminants inhaled. In general, if properly fitted and worn, the typical half-face air-purifying respirator provides a protection factor of 10. A full-face air-purifying respirator provides a protection factor of 50.

The cartridges or canisters of air-purifying respirators have a limited capacity to protect against toxic gases and vapors in the air. Theoretically, cartridges and canisters are effective against toxic vapors and gases until their capacity is exhausted; then the vapor or gas passes through the cartridge or canister and into the inside of the respirator. If you detect an odor or taste, or feel eye or throat irritation, leave the hazardous area immediately; go to a safe area that contains uncontaminated air. Then inspect your respirator for any physical failure. You must change the cartridge or canister on the respirator if no physical problems are detected. Because canisters and cartridges have a limited capacity and many pesticides lack warning properties (odor or irritation), DPR regulations require that air-purifying elements be replaced according to the most frequent of the following:

- pesticide labeling directions
- equipment manufacturer's recommendations
- at first indication of odor, taste or irritation
- at the end of each day's work period.

Air-purifying respirators (canister or cartridge) do not provide oxygen to the wearer. Do not use these respirators in situations where oxygen content of the air might be low. In these situations, use equipment capable of providing an independent source of breathing quality air, such as a SCBA or an air-line respirator.

Employees with facial hair cannot work where respiratory protection is required unless provided with a respirator that does not require a face-to-facepiece seal for proper operation.

Respirators only protect from inhalation exposure. In many pesticide use situations, protection from dermal exposure is probably also necessary.

Information Sources:

Additional information is available from several organizations and individuals. The following list provides sources for safety equipment and information:

1. Safety equipment retailers - see local telephone directory yellow pages.
2. Occupational safety and health consultants
3. Department of Pesticide Regulation, Worker Health and Safety Branch, 830 K Street, Sacramento, California 95814, (916) 445-4222.
4. County Agricultural Commissioner - see listing under County Government Offices, Agricultural Commissioner.
5. Cal/OSHA Consultation Service - see listing under State Government Offices, Industrial Relations Department, in local telephone directory.
6. County Health Department
7. Insurance carriers

Exemptions:

Users of antimicrobials (used only as sanitizers, disinfectants or medical sterilants) or pool and spa chemicals are exempt from complying with these provisions, provided you follow applicable sections of Title 8 of the California Code of Regulations. Applicable sections for respiratory protection include sections 3380 through 3385 and 5144.

In addition, these requirements do not apply to employees handling consumer products, if exposure is similar to that of the consumer.

This leaflet assists readers in understanding pesticide regulations. It is not a legal document. The California Code of Regulations, Title 3 is the legal reference for the requirements in this document. The words "must" and "should" used in the text are not the same. The word "must" means the action is required and comes from California regulations. The word "should" means additional handling practices that are recommended to further reduce exposure.

D. Gibbons & S. Edmiston

SAMPLE WRITTEN SITE SPECIFIC OPERATING PROCEDURES FOR THE SELECTION AND USE OF RESPIRATORS

RESPIRATORY PROTECTION PROGRAM

Company Name____

Address____

____

Person Responsible for Program____

I. Selection of Respirators

In the following pesticide-related uses, we require respirator use.

____

____

We base our selection of respirators on:

____

Personnel and selected respirator(s)

Employee	Respirator
________________________________	________________________________
________________________________	________________________________
________________________________	________________________________

Additionally, we have an area(s) or time(s) where emergency respiratory protection is necessary.

____

For this use, we have selected the following respirator(s).

____

II. Use of Respirators

The above employees received respiratory protection training. ____________ (name)________________ conducted the initial training on ___________________. Attached is a list of more recent training.

On a periodic basis __________(name)_________ conducts a routine inspection of respiratory gear. Inspect equipment kept for emergency use at least monthly. Keep a record of the most recent inspection on the respirator or its storage container.

EMPLOYEE STATEMENT OF MEDICAL CONDITION

____

(Print Employee Name)

In accordance of Section 6738 of the California Code of Regulations, to the best of my knowledge, I have (_), have no (_) medical conditions which would interfere with wearing a respirator while engaged in potential pesticide exposure situations. I understand that heart disease, high blood pressure, lung disease or presence of a perforated ear drum require specific medical evaluation by a physician before safe use of a respirator can be determined.

______________________________ ____________________

(Signature of Employee) (Date)

REPORT OF MEDICAL EVALUATION

In accordance with Section 6738 of the California Code of Regulations, I examined the employee listed above. For the employee named above, there is no current medical contraindication to wearing a respirator while working in potential pesticide exposure environments.

Other Comments:____

____

____

____

(Printed Physician's Name)

______________________________ ____________________

(Physician's Signature) (Date)

Pesticide Safety Information
Worker Health and Safety Branch
Series N

N-6 SUMMARY OF WORKER SAFETY REGULATIONS FOR THE NONCROP SETTING

CALIFORNIA CODE OF REGULATIONS (CCR) TITLE 3, DIVISION 6

The pesticide worker safety regulations specify safe work practices for employees who handle pesticides. The term "handle" refers to any activity related to the application of pesticides. Handle includes mixing, loading, applying, repairing or cleaning contaminated equipment, and handling unrinsed containers. The Department of Pesticide Regulation and the local agricultural commissioner enforce the worker safety regulations. Important requirements of the regulations follow.

Employer/Employee Responsibilities (CCR 6702):

Employers must:

- know the regulations and requirements on pesticide labeling
- tell you, in a language you understand, about the pesticides used, pesticide safety hazards, personal protective equipment required, other equipment used, work procedures, and pesticide safety regulations
- ensure that their employees work safely and follow all safety rules.

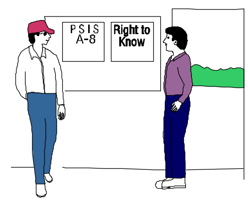
Employees must:

- use the personal protective equipment (PPE)
- follow safety rules in regulations and on pesticide labeling.

Hazard Communication (CCR 6723, 6723.1):

Hazard communication ensures that you know the hazards you may face and what to do to protect yourself from those hazards. Through proper hazard communication, you will know about the hazards, safe work practices and where records are kept. Pesticide Safety Information Series (PSIS) leaflet N-8, is the written hazard communication program for handlers. Your employer must display it for you to read. Your employer must also display the following for pesticide handlers to read:

- time and date of applications
- pesticide product name, active ingredient and EPA registration number



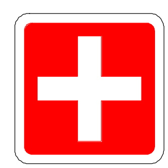
Your employer must make available to you:

- Material Safety Data Sheets (MSDS) for the pesticides used, if available
- PSIS leaflets applicable to the use situation

Training (CCR 6724, 6764):

If you handle pesticides, you must receive adequate training in the use of the pesticides. Training must occur <u>before</u> you begin to handle pesticides. Handlers must receive refresher training each year. Training of handlers must include the following for each pesticide or group of chemically similar pesticides (such as organophosphates):

- the meaning of information on the pesticide label concerning human health effects
- hazards of the pesticide, including acute and long term effects
- routine and emergency decontamination procedures
- symptoms of pesticide poisoning
- emergency first aid
- how to get emergency medical care


FIRST AID

- routes pesticides can enter your body
- need, limitations, use and cleaning of required PPE
- prevention, recognition and first aid for heat-related illnesses
- safety requirements for handling pesticides
- environmental concerns
- warnings about taking pesticides home

- regulatory requirements, MSDS, and PSIS
- your rights as an employee
- location of the written hazard communication program.

Once training is received, you must sign the training record. Records of your training must be kept at your work headquarters.

You have the right to receive information about pesticides to which you may be exposed (or it can be given to your physician). You cannot be fired for exercising your rights.

Labels and Other Warnings (CCR 6602, 6618, 6674, 6678):

Pesticide labels must be available at the work site. If pesticides are transferred from their original container, the new container must be labeled with the identity of the pesticide, the signal word from the product label and the name of the person or firm responsible.

Before applying pesticides, the applicator must notify the person responsible for the property of the application. The notice must include:

- the date of the application
- the pesticide brand name or chemical name
- safety precautions required by label or regulations

The person responsible for the property must warn all persons on the property or likely to enter during application. The warning must include:

- date of the application
- the pesticide brand name or chemical name
- safety precautions required by label or regulations

Use Records (CCR 6624):

Records about when and where pesticides were used must be kept for most pesticide use situations. If your employer is required to keep use records, you have the right to see those records.

Emergency Medical Care (CCR 6726):

If you handle pesticides, your employer must make prior arrangements for emergency medical care, and tell you the location of the medical facility in case someone is sick or injured on the job. If you handle pesticides, your employer must post the following in a prominent place:

- the name, address and telephone number of the physician, clinic or emergency room able to provide care
- This information can also be posted in your work vehicle if there is no fixed work site.

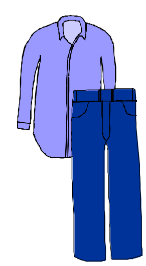
Decontamination and Hygiene (CCR 6732, 6734):

If you handle pesticides with the signal word "DANGER" or "WARNING", your employer must provide water, soap and towels for routine washing. There also must be water for emergency eye flushing and washing of the whole body. This decontamination site must be within 100 feet of the mixing/loading site.

In addition, your employer must provide a place to wash and change clothing after work, if you regularly handle pesticides that have the signal word "DANGER" or "WARNING." A change area is also required if you handle a pesticide for any length of time that is on the minimal exposure pesticide list.

Coveralls (CCR 6736, 6793):

Your employer must provide clean coveralls (1- or 2-piece garment that covers the body, except head, hands and feet) each day you handle pesticides with the signal word "DANGER" or "WARNING" or any minimal exposure pesticide. Your employer is responsible for washing coveralls. Washing <u>other</u> contaminated clothing is discussed in PSIS N-7.



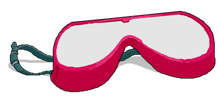
Engineering Controls (CCR 6742, 6746, 6793):

Engineering controls are methods used to reduce exposure (closed system, water soluble packaging, etc.) other than personal protective equipment (respirators, gloves, etc.). Handlers may substitute personal protective equipment when using certain engineering controls. See PSIS N-3 for further explanation of engineering controls and allowed substitutions.

All application equipment must be inspected prior to use. Any repairs necessary must be made prior to use. Tanks on pesticide equipment used must have covers to prevent spills when in use.

Personal Protective Equipment (CCR 6738, 6793):
Your employers must provide all necessary personal protective equipment (PPE) and ensure it is clean and in good repair. You should not take that PPE home to be washed. Generally, the label lists the necessary PPE for the pesticide used. However, in California there are additional requirements that may not appear on labels. Some of these requirements follow:

Eye protection - Eye protection is required in the following situations:



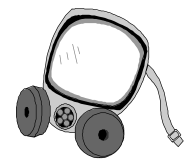
- when stated on the label
- mixing/loading
- adjusting, cleaning or repairing pesticide-handling equipment
- ground application, except when injecting or incorporating pesticides into the soil, working in an enclosed cab or when spray nozzles are located below you and pointed downward
- hand application, except when applying vertebrate baits, using solid fumigants, baiting insect monitoring traps or applying non-insecticidal lures

Eye protection includes safety glasses (with front, brow and temple protection), goggles, face shield, or a full-face mask as part of respiratory protection. Regular eyeglasses or sunglasses DO NOT meet this requirement.

Gloves - Wear gloves when:
- required by the pesticide label
- mixing and loading
- adjusting, cleaning or repairing contaminated equipment
- all hand application activities (except vertebrate pest control using long-handled tools).

Gloves must be replaced or washed every day. It is especially important that gloves be washed on the inside as well as the outside, since residue can accumulate inside. DO NOT use leather or cotton gloves unless expressly permitted by the pesticide label.

Respiratory Equipment - When respiratory protection is required, your employer must adopt written procedures for selecting, fitting, cleaning and maintaining the equipment. Employees with certain medical conditions, such as heart or a physician must evaluate lung disease, before being assigned to this kind of work. PSIS N-5 contains additional information on respiratory protection.



Chemical Resistant Clothing - Some pesticides with unusual hazards require the use of chemical resistant suits, footwear, head covering and/or apron. Use of this kind of clothing in warm temperatures may result in heat stress. Since the hazards of the pesticide will not allow its use without this kind of protection, the following rule applies if wearing the chemical resistant suit: Employees are prohibited from using pesticides with this clothing requirement when the temperature is above 80°F during the day or 85°F at night unless they are provided with cooled chemical suits. Some substitutions are allowed for chemical resistant clothing when using engineering controls (see PSIS N-3).

Cleaning/Repairing Equipment (CCR 6744):
If you clean or repair pesticide equipment, you must be fully informed of and protected from the hazards of working on that equipment.

Fumigants (CCR 6780, 6782, 6784):
Fumigants are pesticides used as a gas. A permissible exposure level (PEL) is established for most fumigants. These PELs must not be exceeded. It is your employer's responsibility to know that you are not being overexposed or to provide approved respiratory protection. Where fumigants are used, your employer must have an accident response plan that tells you what to do in case of a spill, leak or fire. You must know what is in the plan.

You cannot detect some fumigants by odor, taste, irritation or sight. For these fumigants, your employer must know or anticipate possible exposure from routine work activities. Your employer must determine whether:
- your exposure does not exceed the PEL, in which case no respiratory protection is required during those times

- your exposure will exceed the PEL, in which case approved respiratory protection is required
- employee exposure is variable (that is, there are times when the levels exceed the PEL and times when it does not).

You must wear approved respiratory protection all of the uncertain times unless there is continuous monitoring at the work site. If there is continuous monitoring, respiratory equipment is necessary only when monitors indicate air levels are over the PEL.

Two trained employees must be present when fumigating enclosed spaces. Post warning signs prior to the fumigation of enclosed spaces.

Minimal Exposure Pesticides (CCR 6790-6793):

The following pesticides are on the minimal exposure pesticide (MEP) list:

- propargite (Omite®, Comite®) - agricultural pesticide
- folpet - nonagricultural pesticide
- bromoxynil (Buctril®) - agricultural and nonagricultural pesticide
- oxydemeton-methyl (Metasystox®-R) - agricultural and nonagricultural pesticide

The hazards of using these pesticides require special safety rules regardless of the toxicity category of the pesticide. These rules are:

- a change area must be provided
- washing facilities must be at all mix/load sites
- clean work clothing must be provided each day;
- a closed system must be used for liquid pesticides or liquid dilutions of pesticides
- handlers of MEPs must wear clean or new chemical resistant suits (except when using some engineering controls - see PSIS N-3)
- use respiratory protection when applying by hand or ground (except when using some engineering controls).

Exemptions:

The worker safety requirements do not apply to employees handling consumer products that are for general public use as long as employee exposure is not greater than expected consumer exposure.

When antimicrobials (used only as sanitizers, disinfectants and medical sterilants) or pool and spa chemicals are used, your employer does not have to follow these regulations, provided Cal/OSHA regulations are followed.

You may examine a complete set of these regulations at your local county agricultural commissioner's office.

This leaflet assists readers in understanding pesticide regulations. It is not a legal document. The legal reference can be found in the California Code of Regulations, Title 3. The words "must" and "should" used in the text are not the same. The word "must" means the action is required and comes from California regulations. The word "should" means additional handling practices that are recommended to further reduce exposure.

N-7 LAUNDERING PESTICIDE CONTAMINATED CLOTHING FOLLOWING USE OF NONAGRICULTURAL PESTICIDES

General Information:
This leaflet provides information about removing pesticide residues with non-commercial laundry machines. The clothing of other family members may become contaminated, if pesticide-contaminated clothing contacts other clothing in the wash. In addition, persons handling that clothing may get pesticides on their skin if not properly protected. If you follow the information in this guideline pesticide exposure of persons doing the laundry and their family should be minimized.

California pesticide worker safety regulations require employers to provide clean coveralls for each employee who handles pesticides (mixes, loads, applies, and repairs or cleans pesticide-contaminated equipment) with the signal word "Warning" or "Danger." Coveralls are a one- or two-piece garment that covers the body except for head, hands and feet. Your employer must ensure that you wear clean coveralls at the start of each work day and change out of that clothing and wash at the end of the work day when you handle pesticides with the signal word "Danger" or "Warning". You should not take potentially contaminated coveralls home. If your work day does not involve a return to your headquarters, you must:

- remove your contaminated coveralls at work
- store them in a sealable container outside your living quarters
- return them to the employer.

Always store contaminated personal protective equipment (PPE) separately from clean coveralls. It is your employer's responsibility to provide for the washing of coveralls, and to inform the person doing the laundry that the clothing may be contaminated with pesticides and should be washed separately.

Normal work clothing (even under coveralls or other PPE) can become contaminated with pesticides. In addition, your clothing may be contaminated if you work around treated plants or lawns. When washing any pesticide contaminated clothing with home laundry equipment, do it in a manner that prevents exposure of family members to unwashed clothing or the rinse water.

If you spill very toxic pesticide concentrate on your clothing, take them off immediately. Do not launder; dispose of the clothes according to state and local laws. Throw away leather items contaminated with pesticides; they cannot be adequately cleaned. Wash contaminated clothing as soon as possible.

Laundering Contaminated Clothing:
Consider the following measures when washing pesticide-contaminated clothing at home.

Precautions and Personal Protection.

- Wear rubber gloves when handling contaminated clothing.
- Keep all contaminated clothing in closed plastic bags outside the house, out of the reach of children and pets, until ready to wash.
- DO NOT put in the family laundry basket.
- Multiple washings of clothing may be necessary if contaminated with extremely toxic pesticides.
- Wash hands immediately after handling pesticide contaminated clothing.

Loading the Washer.

- Wash contaminated clothing separately from the rest of the family laundry.
- If possible, use a separate washer.
- Dump contaminated clothing directly into the washer from the plastic bag.
- Keep the washing area well ventilated.

Load Size.

- Place only a few pieces of clothing into the washer at one time.
- It will help ensure good agitation.

Pre-rinse.

- In an automatic washer, allow the washer to agitate and spin the first wash water out in order to dilute pesticide and increase removal.
- Then run through the full wash cycle.
- If your washer doesn't have a pre-soak cycle, run clothing through the wash cycle twice.

Water Level.

- Set the washer to the extra large or large load setting to flush clothing thoroughly and dilute any pesticide present.

Water Temperature.

- Use the HOT water setting.
- Hot water increases pesticide removal.

Wash Cycle.

- Use the LONGEST wash cycle.
- A double rinse is recommended.

Detergent.

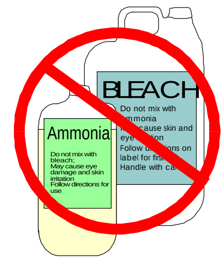
- Use a HEAVY-DUTY liquid or powdered detergent as recommended on the package.
- If there is a stain, use a prewash stain and soil remover. Remember to use rubber gloves when handling clothing.

Water Hardness.

- Hard water can deactivate detergent, and thus can affect pesticide removal.
- Use a mechanical water softener in areas with hard water.

Additives.

- Neither bleach nor ammonia seems to affect removal of most pesticides.
- Never use both, since this combination forms a highly toxic gas.



Cleaning the Washing Machine.

- After laundering pesticide-contaminated clothing, clean the washing machine.
- Run it empty through a complete cycle, using hot water and detergent.

Drying.

- Line drying is the preferred method.
- It will prevent contamination of the dryer, and the sunlight may also help degrade any remaining pesticide residues.
- When using a dryer, run it until the clothing is completely dry.
- After drying, run the empty dryer for about 10 minutes.

Tips for Reducing Pesticide Exposure of Family Members:

- Remove contaminated clothing at the work site and put in plastic bags.
- Empty pockets and cuffs at the work site.
- Shower at the end of the work day. Use clean water and soap.
- Inform the person doing the laundry at home that the clothing is pesticide-contaminated and how to launder it.

REMEMBER: It is you employer's responsibility to wash contaminated coveralls and other PPE that he provides to you to use on the job.

N-10 MINIMAL EXPOSURE PESTICIDES In Noncrop Settings

General Information:

The Minimal Exposure Pesticide (MEP) list was established to inform users about pesticides with hazards not identified by the well known label signal word system of "DANGER", "WARNING" or "CAUTION". Every pesticide label contains one of these signal words. The use of signal words began many years ago. The U.S. Environmental Protection Agency continued use of the signal words when given authority to regulate pesticides by the U.S. Congress in 1972. Signal words give the user a good idea of the pesticide's ability to cause immediate (acute) illness or injury.

We are learning that some pesticides may cause other kinds of health effects. If exposed to these pesticides, you may not notice any effects for a long time after the exposure. Some of these health effects (like cancer) can be caused by exposure to small amounts of pesticide over a long period of time. Other effects (such as birth defects) may be caused by exposure to very small amounts of pesticide at a critical time. These types of adverse effects are not identified by the signal words on the label. Because of these problems, the Minimal Exposure Pesticide regulations were developed to inform workers about the potential effects of some pesticides.

Some MEP labels will have the signal word "CAUTION" on them. This normally means that a worker handling that particular pesticide might not need to be as careful when handling it. This is not true for MEPs. One may not become sick or injured, at least not right away, from excessive exposure to a pesticide on the MEP list. But, that exposure could be doing damage in your body if handled carelessly.

Minimal Exposure Pesticides:

1. Bromoxynil (Buctril®)
   Bromoxynil is a herbicide primarily used to kill weeds in agricultural crops. However, there are some noncrop uses; these include rights-of-way, landscape maintenance, and ornamental turf. In experimental animals, it has been shown to cause birth defects and harmful effects in the pregnant animal. These effects may occur at very low levels of exposure.

2. Oxydemeton-methyl (Metasystox-R)
   Oxydemeton-methyl is an insecticide and miticide used on primarily on fruit, nut and vegetable crops. It too has noncrop uses; these include landscape maintenance and rights-of-way. Oxydemeton-methyl affects an enzyme necessary for proper functioning of the nervous system. Acute poisoning leads to symptoms like headache, nausea, vomiting, weakness and blurred vision. Oxydemeton-methyl caused adverse effects on the male reproductive system at very low levels.

3. Propargite (Omite®, Comite®)
   Propargite is used only in the production of agricultural crops.

Folpet is also listed as an MEP. However, currently the only products registered are paints, coatings and caulkings. These products are exempt from the MEP requirements.

MEP Use Requirements:

The MEP regulations apply regardless of the signal word on the label. In addition to following the safety precautions on the label and in California regulations, your employer must provide the following if you handle MEPs:

- An area with clean towels, soap and water where workers can change clothes and wash at the end of the day
- A clean, pesticide-free place for employees to store personal clothing not in use while handling pesticides
- Clean towels, soap and clean water at the mix/load site for routine or emergency washing
- Clean coveralls (one- or two-piece garment that covers the body except the head, hands and feet); your employer must ensure that you start each work day with clean coveralls
- A closed system for mixing and loading, except for employees who handle a total of one gallon or less per day in original containers of one gallon or less
- Clean full-body, chemical resistant clothing that covers the head, torso, arms, hands, legs and feet
- Appropriate, clean respiratory protection.

Exemptions And Additional Precautions:

Oxydemeton-methyl

- Application to ornamental landscape trees and shrubs must be made by trunk injection or soil injection methods only

There are some general exemptions to the MEP requirements for full body protective clothing when using engineering controls. The following table explains those substitutions allowed.

This leaflet assists readers in understanding pesticide regulations. It is not a legal document. The legal reference can be found in the California Code of Regulations, Title 3. The words "must" and "should" used in the text are not the same. The word "must" means the action is required and comes from California regulations. The word "should" means additional handling practices that are recommended to further reduce exposure.

Allowed Substitutions for PPE When Using Engineering Controls

When using the following:	Handlers may substitute:*	For the following:
Closed system for pesticides with "Danger" or "Warning"	Coveralls, chemical resistant gloves and chemical resistant apron	PPE required on the pesticide labeling
Closed system for pesticides with “Caution”	Work clothing	PPE required on the pesticide labeling
Closed system under positive pressure	Protective eyewear**	
Mixing pesticides in water soluble packets	Use in water soluble packets***	Use of a closed mixing system
Enclosed cab	Work clothing and respiratory protection required	PPE required on the pesticide labeling
Enclosed cab acceptable for respiratory protection	Work clothing	PPE required on the pesticide labeling
Any pesticide	Chemical resistant suit	Coveralls and a chemical resistant apron

* For any substitution, all PPE required by the label must be available in case of an emergency

** Protective eyewear is required in addition to coveralls, chemical resistant gloves and apron for pesticides with "Danger" or "Warning" or in addition to work clothing for pesticides with "Caution" on the label

*** Using pesticides in water soluble packets is equivalent to mixing with a closed system. However, transfer from mix tank to application tank must be made with closed transfer equipment.

N-8 HAZARD COMMUNICATION FOR EMPLOYEES HANDLING PESTICIDES IN NONCROP SETTINGS*

*** Employers: Fill in the blank lines on this page and display this handout at the employee's work site.**

General:

This handout tells you about your right to know the pesticide dangers at work and about the Department of Pesticide Regulation (DPR) rules on "Hazard Communication" in California. "Hazard Communication" is a program to make sure you know about the dangers at work, how to protect yourself from those dangers, and where to get information about the dangers and safety procedures.

Pesticides are chemicals commonly used on to kill insects, weeds, germs and plant diseases on farms, as well as, in non-agricultural settings (landscape, parks, restaurants or hospitals). Fertilizers are not pesticides.

The label on the pesticide, training, and other forms of warning tell you of the dangers. Your boss must know and tell you (in a language you understand) about the pesticides you will use, and how to protect yourself and safely use them.

Your Rights As An Employee:

By law you must be told about possible dangers where you work. You must also be trained to recognize and avoid those dangers. As an employee you have the following rights:

- You have the right to know what pesticides were sprayed and to look at the application records. The required records are kept at:

  ____

  ____

  ____
- You have the right to file a complaint about the dangers at work without being punished or fired. Your boss will not be told who filed the complaint.
- You have the right to look at Material Safety Data Sheets (MSDS), if available, for each pesticide used. These documents tell you about the pesticides and their dangers.
- Your boss must plan ahead for medical care and make sure that you are taken to the doctor if you get sick or hurt because of pesticides at your job. Medical care is available for you at:

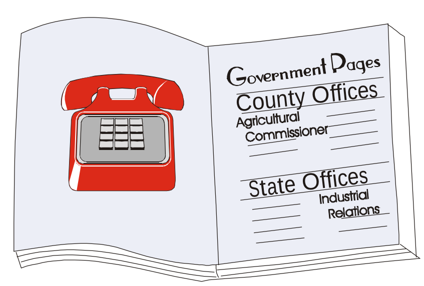
  ____

  ____

  ____
- If you get sick or injured on the job, you have the right to file a claim for worker's compensation. Workers' compensation will pay for your medical costs, and in some cases, lost pay.

Your boss will explain your rights to you. If you need more help in understanding your rights, you may contact the local county agricultural commissioner's office, the local legal aid or worker's rights office, your union or DPR at: Anaheim (714) 680-7800; Fresno (559) 445-5401 or Sacramento (916) 372-6892.

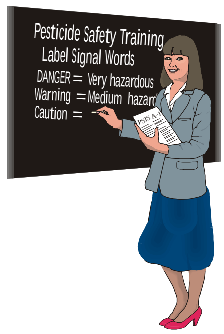
Pesticides are only one kind of danger at your work. Complaints about pesticide dangers should be filed with the county agricultural commissioner. Complaints about other safety problems should be filed with the California Department of Industrial Relations-Cal/OSHA office. The telephone numbers can be found in the government pages of the telephone book.



California Environmental Protection Agency
Department of Pesticide Regulation
830 K Street, Sacramento, California 95814-3510

Training/Education:

Training is one important way to learn about pesticide dangers and how to protect yourself from the pesticide. If you work with pesticides, you must be given training about using pesticides and pesticide equipment safely. The training must occur before you begin to work with pesticides. You must be given refresher training each year to help remind you how to handle pesticides safely. You must know the immediate and long-term dangers the pesticides can cause and how to safely use the pesticides you will work with. Pesticide Safety Information Series (PSIS) handout N-1 tells you everything that must be part of your pesticide training. Extra training is needed if you use respirators (see PSIS handout N-5). All information that was part of your training must be written down and you must sign the paper to show you have been trained, but only after you have finished the training.



You must be told where you can see the work-related papers that must be made available to you (see Table 2). You do not need to ask your boss' permission to look at these records.

Hazard Identification:

The pesticide label tells you what chemicals are in the container, information about the pesticide, first aid, warnings, protective equipment needed and directions for application. Other chemicals, called "inert ingredients", are not usually written on the label. These other ingredients can also make you sick. Doctors who need to know the names of the ingredients to treat you can usually that information from the company who makes the pesticide or from DPR.

Before a pesticide can be used in California, tests are done to find out about its harmful effects. The pesticide label gives you information on the dangers of using the pesticide. All pesticides are poisonous. If you are exposed, they can harm you or make you sick.

- "DANGER" means the pesticide is very poisonous; touching or breathing very small amounts can cause serious harm or sickness.
- "WARNING" means moderate danger; it takes exposure to more pesticide to make you sick or hurt.
- "CAUTION" means the danger is low; it can still cause harm or sickness, but requires contact to much more pesticide

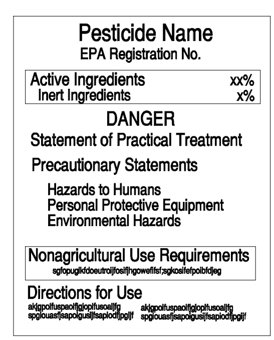
In addition, the label also tells you about more specific dangers and the safety measures you need to follow. You must know and follow those precautions.

- If the pesticide causes serious eye or skin injury, the label will say something like, "Corrosive, causes eye and skin damage."
- If the pesticide can make you very sick, the label will have a skull-and-crossbones symbol and the word "POISON."
- Words like "fatal" or "may be fatal if swallowed, inhaled, or absorbed through the skin" also means the pesticide can make you very sick or cause death if you are exposed to too much.
- Some labels tell you about other health problems such as cancer or birth defects.

You cannot rely only on the pesticide label to tell you of the dangers. Your boss must have a copy of the MSDS for the pesticide(s) sprayed and must tell you where you can go look at it. Other sources of safety information may include industry trade bulletins, and government hazard alerts and other Pesticide Safety Information Series handouts like this one.

Labels And Other Forms Of Warnings:

In addition to training, there are many other ways that information is given to you (see Table 2 on page 4). The pesticide label tells you how to safely mix and apply the pesticide. The label must be at the your work site when you mix or apply the pesticide. Normally this is the label on the pesticide container. It can also be on a "product bulletin" or other additional labeling. If a service container (any container that is not the original factory container) is used, your boss must make sure that the complete label is at your work site. Service containers must be labeled to identify the pesticide, the signal word (Danger, Warning, Caution), and who is responsible for the container and the pesticide in it.



When possible, keep pesticides in their original container with the original label. Never use food, drink, or household product containers for pesticides.

Most places where pesticides are stored must be locked and posted with warning signs. The signs must be in a language you understand. More information on pesticide storage, transportation and disposal is found in PSIS handout N-2.

In 1986, a law called the *Safe Drinking Water and Toxic Enforcement Act of 1986* (Proposition 65) was passed. Proposition 65 requires California to make a list of chemicals that can cause cancer, birth defects, or other reproductive harm. The Proposition 65 list contains many chemicals, including dyes, solvents, pesticides, drugs, and food additives. If a pesticide is on the Proposition 65 list, your boss must warn you if you might be exposed to enough pesticide to result in a significant risk of cancer, birth defects or other reproductive harm. Your boss may also warn you if a pesticide on the Proposition 65 list has been sprayed, even if health problems are not likely. Your boss is required to keep specific information on each pesticide application. You have a right to look at this information; in your training, you should be told where you can find it. If you are unsure of the location, ask your boss. Table 1 lists pesticides that are on the Proposition 65 list and might be used in California.

Table 1
CURRENTLY REGISTERED PESTICIDES ON THE PROPOSITION 65 LIST

PESTICIDES KNOWN TO THE STATE TO CAUSE CANCER

- Alachlor
- Arsenic acid
- Arsenic pentoxide
- Arsenic trioxide
- Cacodylic acid
- Captan
- Chlorothalonil
- Chromic acid
- Creosote
- Daminozide
- DDVP (dichlorvos)
- *p*-Dichlorobenzene
- 1,3-Dichloropropene
- Dioctyl phthalate
- Dipropyl isocinchomeronate (MGK repellent 326)
- Ethylene oxide
- Fenoxycarb
- Folpet
- Formaldehyde (gas)
- Iprodione
- Lindane
- Mancozeb
- Maneb
- Metam sodium
- Metiram
- Oxadiazon
- Oxythioquinox
- Pentachlorophenol
- *o*-Phenylphenate, sodium (*o*-phenylphenol, sodium)
- *o*-Phenylphenol Propargite
- Pronamide (propyzamide)
- Propylene oxide
- Silica aerogel
- Sodium dichromate
- Sodium dimethyldithiocarbamate
- Thiodicarb
- Vinclozolin

PESTICIDES KNOWN TO THE STATE TO CAUSE BIRTH DEFECTS OR REPRODUCTIVE HARM

- Amitraz
- Arsenic, pentoxide
- Arsenic, trioxide
- Benomyl
- Bromacil, lithium salt
- Bromoxynil octanoate
- Chlorsulfuron
- Cyanazine
- Cycloate
- 2,4-D butyric acid (2,4-DB)
- Diclofop methyl
- Disodium cyanodithioimido carbonate
- EPTC (ethyl dipropylthiocarbamate)
- Ethylene oxide
- Fenoxaprop ethyl
- Fluazifop butyl
- Fluvalinate
- Hydramethylnon
- Linuron
- Metam sodium
- Metiram
- Methyl bromide (as a structural fumigant)
- Myclobutanil
- Nabam
- Nicotine
- Nitrapyrin
- Oxadiazon
- Oxydemeton-methyl
- Oxythioquinox
- Potassium dimethyldithiocarbamate
- Propargite
- Resmethrin
- Sodium fluoroacetate (1080)
- Streptomycin sulfate
- Thiophanate methyl
- Triadimefon
- Tributyltin methacrylate
- Triforine
- Vinclozolin
- Warfarin

<u>Records</u>:
There are many papers your boss must keep and make available for you read (see Table 2). These papers can be grouped into two general kinds, training and exposure.

Training. Your boss must keep a written record of the training provided to you.

Exposure. Your boss must keep records for all pesticides you apply .

<u>Emergency Medical Care:</u>
If you become ill or are injured on the job you must be <u>taken</u> for medical care. Do not drive yourself if you are ill or injured.

More information on first aid is available in PSIS handout N-4.

Other PSIS handouts mentioned in this document should be part of your training. They are free and are available from your boss and the local agricultural commissioner's office.

This leaflet helps you to learn about pesticide regulations. It is not a legal document. The legal reference can be found in the California Code of Regulations, Title 3. The words "must" and "should" used in the text are **not** the same. The word "must" means the action is required and comes from California regulations. The word "should" indicates extra safety practices that are recommended to help reduce pesticide exposure.

Table 2

SUMMARY OF "HAZARD COMMUNICATION" RECORDS

Information	Kept for:	Location	Section[1]
Training records	2 years	Boss' office site	6724(e)
Written training program	2 years	Boss' office site	6724(a)
Respirator program procedures	During use	Boss' office site	6738(h)
Accident response plan (fumigants)	During use	Work site	6780(d)
Pesticide Label	During use	Work site	6602
Pesticide Safety Information Series	2 years	Boss' office site	6723(b)
Material Safety Data Sheet	2 years	Boss' office site	6723(b)
Storage area posting[2]	During use	Storage area	6674
Emergency medical care notice	During use	Work site	6726
Medical evaluation (respirator use)	During use	Boss' office site	6738(h)
Pesticide use records	2 years	Boss' office site	6624

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[1] Rules are found in the California Code of Regulations, Title 3 and the section listed in this column
[2] Required only for pesticides with the Signal word "DANGER" or "WARNING"

Your county agricultural commissioner can provide additional information about these requirements.

PART 2

Indoor Pest Management

7.1 Insects and Other Invertebrates

- Ants
- Carpenter Ants
- Carpenter Bees
- Carpet Beetles
- Clothes Moths
- Cockroaches
- Fleas
- Flies
- Head Lice
- Head Lice Information Packet for Schools
- Scorpions in Schools
- Silverbrats and Firebrats
- Spiders
- Termites
- Termites (Drywood)
- Wood-Boring Beetles

7.2 Vertebrates

- House Mouse
- Rats in Schools

ANTS

Integrated Pest Management In and Around the Home

Ants are among the most prevalent pests in households. They are also found in restaurants, hospitals, offices, warehouses, and other buildings where they can find food and water. Once ants have established a colony inside or near a building, they may be difficult to control. On outdoor (and sometimes indoor) plants, ants protect and care for honeydew-producing insects such as aphids, soft scales, whiteflies, and mealybugs, increasing damage from these pests. Ants also perform many useful functions in the environment, such as feeding on other pests (e.g., fleas, caterpillars, termites), dead insects, and decomposing tissue from dead animals.

There are over 12,000 species of ants throughout the world. In California, there are about 200 species but fewer than a dozen are important pests. The most common ant occurring in and around the house and garden in California is the Argentine ant, *Linepithema humile* (formerly *Iridomyrmex humilis*) (Fig. 1). Other common ant pests include the pharaoh ant (*Monomorium pharaonis*), the odorous house ant (*Tapinoma sessile*), the thief ant (*Solenopsis molesta*), and the southern fire ant (*Solenopsis xyloni*). Less common, but of great importance, is the red imported fire ant, *Solenopsis invicta*, which has recently gained a foothold in southern California. In some areas, the spread of the fire ant has been slowed by competition from the Argentine ant.

IDENTIFICATION

Ants belong to the insect order Hymenoptera and are close relatives of bees and wasps. They are familiar insects that are easily recognized, especially in their common wingless adult forms, known as workers. However, winged forms of ants, which leave the nest in large numbers in warm weather to mate and establish new colonies, are often mistaken for winged termites, which also leave their nests to mate. Ants and termites can be distinguished by three main characteristics illustrated in Figure 2.

- The ant's abdomen is constricted where it joins the thorax, giving it the appearance of having a thin waist; the termite's abdomen is broad where it joins the thorax.
- The ant's hind wings are smaller than its front wings; the termite's front and hind wings are about the same size. (Shortly after their flights, both ants and termites remove their wings, so wings may not always be present.)
- Winged female ants and worker ants have elbowed antennae; the termite's antennae are never elbowed.

Ants undergo complete metamorphosis, passing through egg, larval, pupal, and adult stages. Larvae are immobile and wormlike and do not resemble adults. Ants, like many other hymenopterans, are social insects with duties divided among different types, or castes, of adult individuals. Queens conduct the reproductive functions of a colony and are larger than other ants; they lay eggs and sometimes participate in the feeding and grooming of larvae. Female workers, who are sterile, gather food, feed and care for the larvae, build tunnels, and defend the colony; these workers make up the bulk of the colony. Males do not participate in colony activities; their only apparent purpose is to mate with the queens. Few in number, males are fed and cared for by workers.

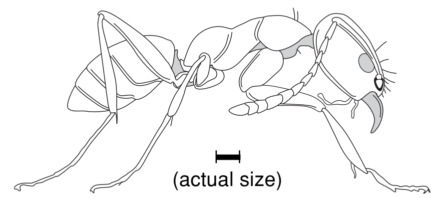

Figure 1. Argentine ant.

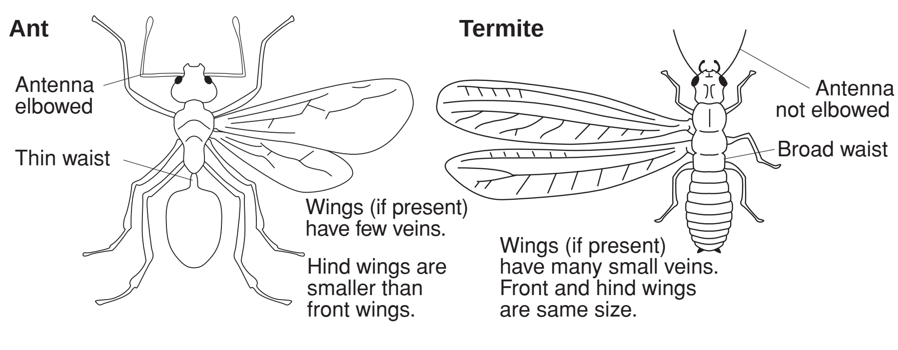

Figure 2. Distinguishing features of ants and termites.

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Adult workers of the Argentine and odorous house ant are about 1/8 inch long and range from light to dark brown in color; those of the pharaoh and thief ant are smaller, measuring about 1/25 inch long. The workers of the southern fire ant vary in size and have a red head and thorax with a black abdomen. Carpenter ants, *Camponotus* spp., also invade buildings in California. Although they do not eat wood as termites do, they hollow it out to nest and may cause considerable damage. These ants vary greatly in size from 1/4 to 3/4 inch long (for more information on carpenter ants, see *Pest Notes*: *Carpenter Ants*, listed in "Suggested Reading"). For color photographs and additional information on identifying the different ant species, see *A Key to the Most Common and/or Economically Important Ants of California*, listed in "Suggested Reading."

DAMAGE

Inside a building, household ants feed on sugars, syrups, honey, fruit juice, fats, and meat. Long trails of thousands of ants may lead from nests to food sources, causing considerable concern among building occupants. Outdoors they are attracted to sweet, sticky secretions, or honeydew, produced by soft scales and aphids. Frequently outbreaks of scales and aphids occur when ants tend them to obtain their sweet secretions because the ants protect scales and aphids from their natural enemies. Ants can bite with their pincerlike jaws, although most species rarely do. A few ants sting; the southern fire ant, which is primarily an outdoor species, is the most common and aggressive stinging ant in California. Another very aggressive stinging ant, the red imported fire ant (*S. invicta*), has recently been found in various southern California counties. Contact your county Cooperative Extension office for information on this new pest.

LIFE CYCLE AND HABITS

Ants usually nest in soil; nests are often found next to buildings, along sidewalks, or in close proximity to food sources such as trees or plants that harbor honeydew-producing insects. They also construct nests under boards, stones, tree stumps or plants, and sometimes under buildings or other protected places. Pharaoh ants like warmth and make nests inside buildings, often in wall voids, under flooring, or near hot water pipes or heating systems. Ant food includes fruits, seeds, nuts, fatty substances, dead or live insects, dead animals, and sweets. Food preferences vary somewhat between ant species.

Ants enter buildings seeking food and water, warmth and shelter, or a refuge from dry, hot weather or flooded conditions. They may appear suddenly in buildings if other food sources become unavailable or weather conditions change.

A new colony is typically established by a single newly mated queen. After weeks or months of confinement underground, she lays her first eggs (Fig. 3). After the eggs hatch, she feeds the white, legless larvae with her own metabolized wing muscles and fat bodies until they pupate. Several weeks later, the pupae transform into sterile female adult workers, and the first workers dig their way out of the nest to collect food for themselves, for the queen (who continues to lay eggs), and for subsequent broods of larvae. As numbers increase, new chambers and galleries are added to the nest. After a few years, the colony begins to produce winged male and female ants, which leave the nest to mate and form new colonies.

Argentine ants differ from most other ant species in California in that they have multiple queens within a nest, they move their nests if disturbed, and in the winter several colonies will nest together. Moreover, when newly mated queens disperse to found new colonies, instead of doing it by themselves they are accompanied by workers.

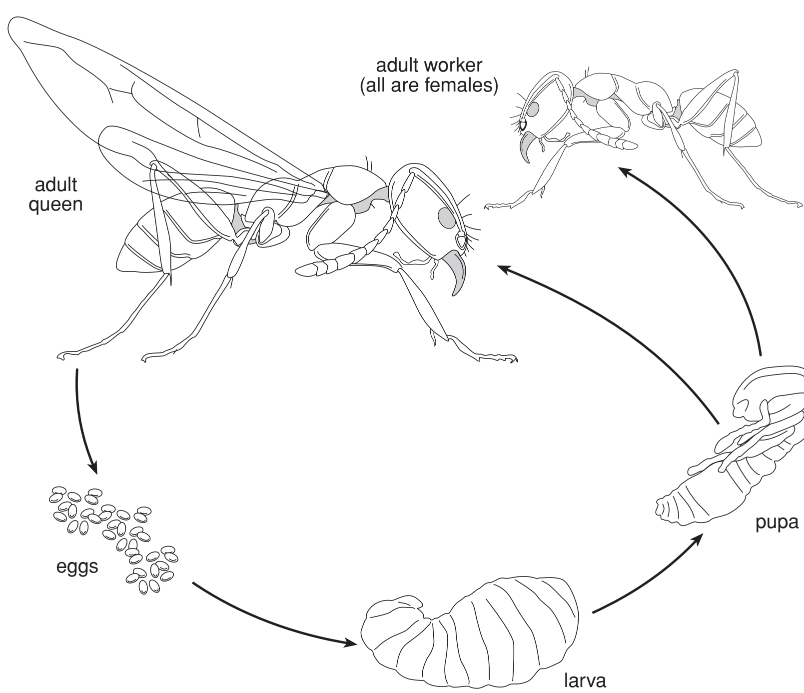

Figure 3. Life cycle of the Argentine ant.

MANAGEMENT

Ant management requires diligent efforts and the combined use of mechanical, cultural, sanitation, and often chemical methods of control. It is unrealistic and impractical to attempt to totally eliminate ants from an outdoor area. Focus your management efforts on excluding ants from buildings or valuable plants and eliminating their food and water sources. Remember that ants play a beneficial role in the garden in some cases. Become aware of the seasonal cycle of ants in your area and be prepared for annual invasions by caulking and baiting before the influx.

Exclusion and Sanitation

To keep ants out of buildings, caulk cracks and crevices around foundations that provide entry from outside. Ants prefer to make trails along structural elements, such as wires and pipes, and frequently use them to enter and travel within a structure to their destination. Indoors, eliminate cracks and crevices wherever possible, especially in kitchens and other food preparation and storage areas. Store attractive food items such as sugar, syrup, honey, and other sweets in closed containers that have been washed to remove residues from outer surfaces. Rinse out empty soft drink containers or remove them from the building. Thoroughly clean up grease and spills. Do not store garbage indoors. Look for indoor nesting sites, such as potted plants. If ants are found, remove the containers from the building, then submerge the pots for 20 minutes in standing water that contains a few drops of liquid soap. Ant nests may be associated with plants that support large populations of honeydew-producing insects. Avoid planting such trees and shrubs next to buildings.

Baits

One way to control ants in and around structures is to use toxic baits. Baits are formulated as solids or liquids and applied in stations or in the case of granules by broadcasting them. Ants are attracted to the bait and carry small portions of it back to the nest where it is given to other workers, larvae, and reproductive forms. To achieve wide distribution of the bait so the entire colony will be killed, the bait toxicant must be slow-acting. Some examples of toxicants used in ant baits are hydramethylnon, boric acid, and fipronil. Hydramethylnon is photodegradable, so if it is broadcasted in granular form it should be applied in the evening. Boric acid is most effective at concentrations of 1% or lower. Fipronil is a new class of toxicant that is effective against ants at ultra-low doses.

Ants will not eat bait if more desirable food is nearby, so be sure to remove any particles of food or other attractive material from cracks around sinks, pantries, and other ant-infested areas of the home. Place bait stations in places where the ants can easily find them, but avoid placing them in areas that are accessible to small children and pets. Place baits where there are ant trails or along edges where ants travel. In addition to placing ant bait stations indoors, space them every 10 to 20 feet outside around the foundation and at nest openings if they can be found. Control with baits is not immediate and may take several weeks or more to be complete. Effectiveness of baits will vary with ant species, bait material, and availability of alternative food. In the case of Argentine ants, sweet baits (e.g., Grant's Ant Stakes, Dr. Moss's Liquid Bait System) are attractive year-round. Protein baits (e.g., Combat ant baits) are more attractive in spring when the colony is producing brood. Offering a small quantity of each kind of bait and observing which is preferred by the ants is a good way to determine what to use.

Indoor Sprays

An insecticide labeled for ant control can provide immediate knockdown of foraging ants if necessary while sanitation and exclusion measures are being taken. However, if ants can be thoroughly washed away and excluded from an area, an insecticide is probably not necessary. Sponging or mopping with soapy water, as an alternative to insecticides, may be as effective in temporarily removing foraging ants in a building because it removes the ant's scent trail.

Outdoor Treatments

To prevent ants from entering buildings, small spot applications can be made at entrance points into the buildings. Pyrethroids (such as bifenthrin and cyfluthrin) are effective for this kind of application. Botanical pyrethrins will kill ants that they contact directly, but do not provide any residual control. Preliminary research on mint-oil products as repellents indicates that they are not effective.

A common method used to prevent ants from coming indoors is to apply a perimeter treatment of residual sprays around the foundation. Perimeter treatments pose more risk of environmental upset than baits in bait stations, don't provide long-term control, and should be used cautiously. Commonly used insecticides include the pyrethroids bifenthrin and lambda-cyhalothrin. Bifenthrin is available in retail products, but lambda-cyhalothrin may only be applied by a licensed pest control professional. Products available to professionals provide a longer residual control than home-use products. Avoid the use of chlorpyrifos and diazinon; landscape and residential use of these materials in urban areas has been identified as a source of pollution for California's creeks and rivers. Apply all pesticides in a manner that prevents runoff into storm drains.

Perimeter treatments by themselves are unlikely to provide long-term control because they kill only foraging workers. For this reason, some companies offer monthly perimeter spray programs. However, for long-term control and environmental safety, rely on exclusion, baits, and other methods that control the colony rather than monthly perimeter treatments.

If colonies need to be controlled outdoors, focus treatment on queens and larvae inside nests; killing foraging workers does little to control the colony because as few as 1% of the workers are able to provide sufficient food for nestbound queens and larvae. Toxic baits provide the easiest way to kill a colony (see "Baits").

Control on Trees and Shrubs

When numerous ants are found on plants, they are probably attracted to the sweet honeydew deposited on the plants by certain sucking insects. These ants can be kept out of trees by band-ing tree trunks with sticky substances such as Tanglefoot. Trim branches to keep them from touching structures or plants so that ants are forced to climb up the trunk to reach the foliage. Protect young or sensitive trees from possible injury by wrapping the trunk with a collar of heavy paper, duct tape, or fabric tree wrap and coating this with the sticky material. Check the sticky material every 1 or 2 weeks and stir it with a stick to prevent the material from getting clogged with debris and dead ants that allows ants to cross.

Enclosed pesticide baits such as ant stakes may be placed near nests or on ant trails beneath plants. For the most effective and economical control, treat in late spring and early summer when ant populations are low.

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Marer, P. 1991. *Residential, Industrial, and Institutional Pest Control*. Oakland: Univ. Calif. Div. Agric. Nat. Res. Publ. 3334.

Moore, W. S., and C. S. Koehler. 1980. *Ants and Their Control*. Oakland: Univ. Calif. Div. Agric. Nat. Res. Leaflet 2526 (out of print).

SUGGESTED READING

Haney, P., P. Phillips, and R. Wagner 1993. *A Key to the Most Common and/or Economically Important Ants of California*. Oakland: Univ. Calif. Div. Agric. Nat. Res. Leaflet 21433.

Mallis, A. 1982. *Handbook of Pest Control*. 6th ed. Cleveland: Franzak & Foster Co.

UC Statewide IPM Project. Oct. 2000. *Pest Notes: Carpenter Ants.* Oakland: Univ. Calif. Div. Agric. Nat. Res. Publ. 7416. Also available online at *http://www.ipm.ucdavis.edu/*

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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WARNING ON THE USE OF CHEMICALS

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Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

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CARPENTER ANTS

Integrated Pest Management In and Around the Home

Several species of carpenter ants, *Camponotus* spp., are capable of damaging wood in buildings and other structures. Carpenter ants cause problems mainly in mountainous areas and in forested rural areas along the central and northern coastlines of California; they may also invade buildings in urban locations.

IDENTIFICATION

Most carpenter ants (Fig. 1) can be easily distinguished from other species of ants by their large size, up to 1/2 inch long. Common species are dark, often black. Carpenter ants cannot sting but if handled can inflict a painful bite with their powerful jaws. They emit a noxious excretion of formic acid when disturbed. Winged ants, which leave the nest to mate and establish new colonies, are sometimes confused with termites (Fig. 2).

LIFE CYCLE

Carpenter ants feed on both dead and living insects, aphid and scale honeydew, and juices of ripe fruit. Carpenter ants enter buildings in search of food and may construct nests containing several thousand individuals somewhere within the building. Nests constructed indoors may be satellite colonies of a larger nest located outside near the building, usually in trees. As many as twenty satellite colonies can be associated with a single main colony that contains the queen(s).

DAMAGE

Although ants do not eat wood, they bore into wood to make their nests, which consist of extensive networks of galleries usually begun in areas soft from decay. Indoor carpenter ant nests are bored into wooden parts of the building, sometimes causing serious structural damage. They also nest in wall voids, hollow doors, cracks and crevices, furniture, and termite galleries. Infestations can occur in new buildings when land clearing in the area disturbs existing native colonies. In the wild, carpenter ants nest in soil and beneath rocks; they bore into living and dead trees and stumps.

MANAGEMENT

Exclude carpenter ants from buildings by caulking cracks and blocking other entrances whenever possible. Trim branches and limbs of trees and shrubs that touch the building to keep ants from gaining access to these routes. Eliminate food sources inside the building or prevent access to suitable food by keeping it in ant-proof containers. Use a mulch, such as gravel or stones, around the perimeter of the building to discourage nest building. Locate and destroy colonies in tree stumps and other nearby places. Eliminate damp conditions that promote wood decay. Replace decayed or damaged wood and correct problems that caused the decay, such as clogged rain

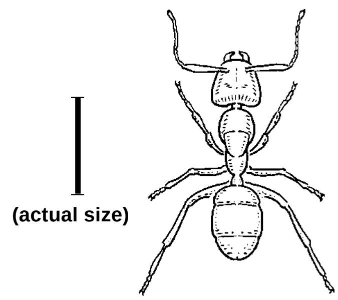

Figure 1. Carpenter ant adult.

gutters. Increase ventilation to damp areas beneath the building and in attics. Store firewood up off the ground and several feet away from buildings to discourage carpenter ant colonies.

Search for nesting sites in the building. Nests may be located by observing ant activity and following their trails, especially during the night because many species are nocturnal. To attract the ants, set out food such as a mixture of sugar and milk or sliced up crickets and then follow the workers back to the nest. Try to find the gallery open-

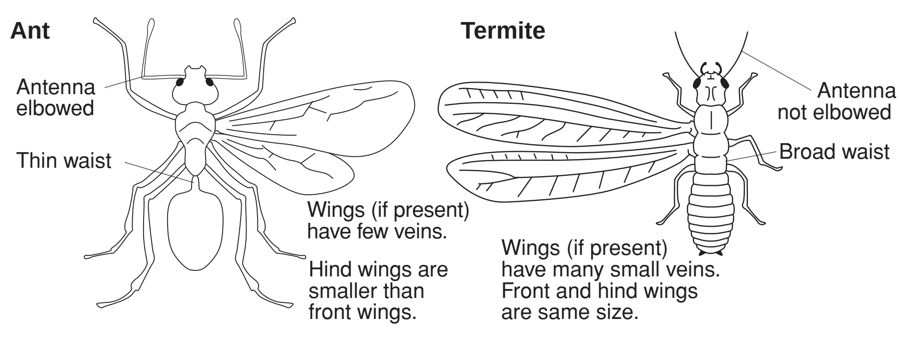

Figure 2. Distinguishing features of ants and termites.

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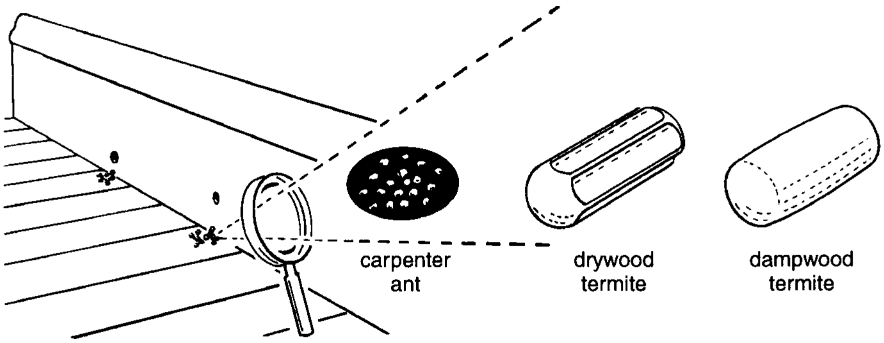

Figure 3. The sawdust produced by carpenter ants is distinctly different from pelletized frass produced by termites.

ings, which are usually small oval holes. Look for sawdust accumulations associated with these openings. Carpenter ant sawdust is considerably different from the pelletized frass left by drywood termites (Fig. 3). Once colony openings are located, apply insecticide formulations (containing materials such as permethrin, cyfluthrin, boric acid, or disodium octaborate tetrahydrate) or desiccant dusts through these openings and other holes drilled into the galleries. Desiccant dusts are inert dusts combined with absorptive powders (diatomaceous earth or silica gel) that destroy insects by absorbing their protective outer body cover, causing them to dry out, or desiccate. Of the desiccant dusts, diatomaceous earth is readily available in retail stores, but silica gel may only be applied by a licensed pesticide applicator. Desiccant dusts are low in toxicity to people and do not lose their effectiveness over time, as long as they do not get wet. Avoid inhaling these materials, however, because they can cause serious lung irritation. Also, avoid the use of chlorpyrifos and diazinon; landscape and residential use of these materials in urban areas has been identified as a source of pollution for California's creeks and rivers.

If you use toxic baits, be sure to use slow-acting formulations so that the ants carry it back to reproductives and larvae deep inside the nest. This is important because fewer than 10% of the worker ants are out foraging at any one time. Boric acid baits that have a low concentration (less than 1%) of the active ingredient and are formulated in a sweet liquid are slow acting and nonrepellent. Because carpenter ants can be finicky eaters, first attract them to a nontoxic food like a sugar-milk solution or sliced crickets. Once they are feeding from this food source, replace it with several different toxic baits that are labeled for ant control, and let them choose the one they prefer. When selecting any insecticide, be sure it lists ants on the label.

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CARPENTER BEES

Integrated Pest Management In and Around the Home

Carpenter bees build nests in wood, creating galleries that can weaken structures; however, they rarely cause severe damage. People may be frightened by carpenter bees because of their large size, their similarity to bumble bees, and their annoying noise.

IDENTIFICATION

Most carpenter bees, *Xylocopa* spp., are large and robust insects (Fig. 1) resembling bumble bees. They are usually about 1 inch long and colored a metallic blue-black with green or purplish reflections. They differ from bumble bees in that they have a shiny, hairless abdomen. Males of some species are lighter colored, ranging into golden or buff hues.

LIFE CYCLE

Female carpenter bees bore into sound or sometimes decaying wood to make nests. Nests usually consist of tunnels 1/2 inch in diameter and 6 to 10 inches deep, partitioned into several chambers, each containing an egg and a supply of food (pollen). Carpenter bees may use old tunnels for their nests, and sometimes enlarge these; several bees may use a common entry hole connecting to different tunnels. Over a period of time, tunnels may extend as far as 10 feet into wood timbers. Tunnels are vacated after the brood's larval and pupal stages complete their development. Development from egg to adult may take about 3 months. Carpenter bees overwinter as adults, often in old tunnels, and there is only one generation a year.

DAMAGE

Carpenter bees cause damage to wooden structures by boring into timbers and siding to prepare nests. Carpenter bee nests weaken structural wood and leave unsightly holes and stains on building surfaces. Sound, undecayed wood without paint or bark is usually selected for nests. Carpenter bees also frequently attack dead wood on trees or lumber from southern yellow pine, white pine, California redwood, cedar, Douglas fir, cypress, mimosa, mulberry, ash, and pecan trees. They avoid most harder woods. The presence of carpenter bees around buildings and wooden structures can be annoying or even frightening; however, males cannot sting and females rarely attack.

MANAGEMENT

Prevention is the main approach to managing carpenter bees. If possible, susceptible exterior parts of a building should be constructed out of hardwoods not normally attacked by the bees for nests. On all buildings, fill depressions and cracks in wood surfaces so they are less attractive. Paint or varnish exposed surfaces regularly to reduce weathering. Fill unoccupied holes with steel wool and caulk to prevent their reuse. Wait until after bees have emerged before filling the tunnels. Once filled, paint or varnish the repaired surfaces. Protect rough areas, such as ends of timbers, with wire screening or metal flashing.

Carpenter bees are generally considered beneficial insects because they help pollinate various crop and noncrop plants. Under most conditions they can be successfully controlled using the preventive measures described above. If infestation is high or risk of damage is great, insecticides may be used to augment other methods of control. To do this, treat active nests (those containing eggs, larvae, or pupae) with liquid or dust formulations of insecticides or desiccant dusts. Liquid formulations containing permethrin and cyfluthrin and dusts containing boric acid and carbaryl are currently labeled for use against carpenter bees. Chlorpyrifos is also registered and available both as a liquid formulation and a dust. This material, however, has the potential for contaminating drain water and is not recommended. Desiccant dusts are inert dusts combined with absorptive powders (diatomaceous earth or boric acid) that destroy insects by abrading their protective outer body cover, causing them to dry out. Desiccant dusts are low in toxicity to people and their pets and do not lose their effectiveness over time, so long as they do not get wet. Avoid inhaling these materials, however, because they can cause serious lung irritation.

After the brood is killed, repair holes with steel wool and wood filler, then repaint or varnish the repaired surfaces.

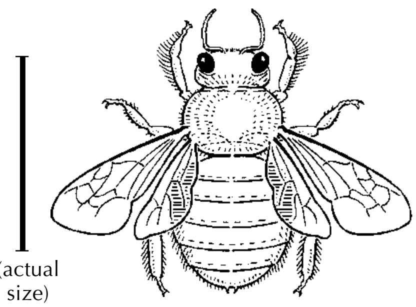

Figure 1. Carpenter bee adult.

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CARPET BEETLES

Integrated Pest Management in the Home

Carpet beetles belong to the family of beetles known as dermestids. These insects are pests in warehouses, homes, museums, and other locations where suitable food exists. In California, three species of carpet beetles cause serious damage to fabrics, carpets, furs, stored foods, and preserved specimens. Their life histories are summarized Figure 1.

IDENTIFICATION AND LIFE CYCLE

All three carpet beetle species have a similar life history. Adults lay eggs on the larval food source, such as furs and woolen fabric or carpets. Eggs hatch in about 2 weeks and the larvae feed for varying periods, depending upon species and environmental conditions. They prefer dark, secluded places. When ready to pupate, the larvae may burrow further into the food or wander and burrow elsewhere. They may also pupate within the last larval skin if no other shelter is available. Larvae do not make webs as clothes moths do, but their shed skins and fecal pellets, which are about the size of a grain of salt, make it obvious where they have been feeding.

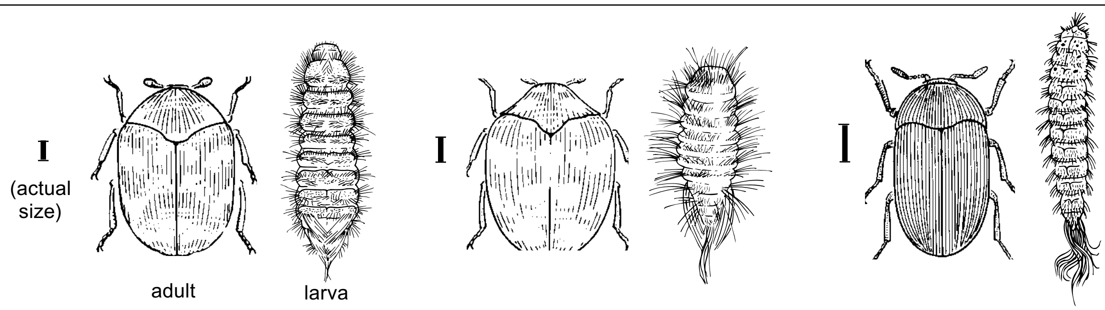
Carpet beetle adults do not feed on fabrics but seek out pollen and nectar. They are attracted to sunlight and are commonly found feeding on the flowers of crape myrtle, spiraea, buckwheat, and other plants that produce abundant pollen. Be careful not to bring these pests into the home on cut flowers—with their rounded bodies and short antennae, carpet beetles somewhat resemble lady beetles in shape.

Varied Carpet Beetle

The varied carpet beetle, *Anthrenus verbasci*, is common in California. The adult is about 1⁄10 inch long and black with an irregular pattern of white, brown, and dark yellow scales on its elytra (wing covers). In older adults the scales that form this pattern wear off so the beetles appear solid brown or black. Outdoors, female beetles search out spider webs and nests of bees, wasps, and birds in which to lay their eggs. The nests contain dead insects, beeswax, pollen, feathers, or other debris that can serve as larval food. Indoors, beetles deposit eggs on or near wool carpets and rugs, woolen goods, animal skins, furs, stuffed animals, leather book bindings, feathers, animal horns, whalebone, hair, silk, dried plant products, and other materials that can serve as larval food.

Mature larvae are about the same length as adults and are covered with dense tufts of hair that they extend upright to form a round plume if disturbed. They have alternating light and dark brown transverse stripes and are distinguishable from other carpet beetle larvae because they are broader

Figure 1. Life histories of three species of carpet beetles.



	Varied Carpet Beetle	Furniture Carpet Beetle	Black Carpet Beetle
number eggs laid	40	60	90
number days to hatch	10–20	9–16	6–16
number days for larval stage	220–630	70–94	166–330
number days for pupation	10–13	14–17	8–14
adult life (weeks)	female 2–6; male 2–4	4–8	4–8

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in the rear and narrower in front. Adults usually appear in spring or early summer; indoors, they are often seen near windows.

Furniture Carpet Beetle

When viewed from above, adults of the furniture carpet beetle, *Anthrenus flavipes*, are slightly larger and rounder than the varied carpet beetle adult. Coloration and markings of the adult are highly variable, but they generally have a mottled appearance due to white and dark yellow to orange scales interspersed with black spots on their elytra; if these scales have been worn off, they may appear solid black. Their undersides are white.

Larvae are white at first but darken to dark red or chestnut brown as they mature. In contrast to larvae of the varied carpet beetle, these larvae are broader in front and narrower at the rear. Larvae of the furniture carpet beetle feed on the same types of items as larvae of the varied carpet beetle.

Black Carpet Beetle

Larvae and adults of the black carpet beetle, *Attagenus megatoma*, are distinctly different from the carpet beetles described above. Adult black carpet beetles range from ⅛ to $\frac{3}{16}$ inch in length. They are shiny black and dark brown with brownish legs. Full-sized larvae may be as long as $\frac{5}{16}$ inch. They range in color from light brown to almost black. Larvae are shiny, smooth, hard, and are covered with short, stiff hairs. Their body tapers toward the rear and ends in a tuft of long hairs.

In California and other arid areas, the black carpet beetle is a more serious stored-product pest than a fabric pest.

DAMAGE

Damage is caused by the larval stage of dermestid beetles. Larvae feed in dark, undisturbed locations on a variety of dead animals and animal products, such as wool, silk, leather, fur, hair brushes with natural bristles, pet hair, and feathers; occasionally they feed on stored products such as certain spices and grains. They do not feed on synthetic fibers.

It is not always possible to tell from the damage whether it was caused by clothes moths or carpet beetles, but in general, the beetles are more likely to damage a large area on one portion of a garment or carpet while moth damage more often appears as scattered holes. Also, carpet beetle larvae leave brown, shell-like, bristly looking cast skins when they molt. These skins and the lack of webbing are usually good clues that the culprits are carpet beetles.

MANAGEMENT

Carpet beetles are among the most difficult indoor pests to control because of their ability to find food in obscure places and to disperse widely throughout a building. Successful control depends on integrating the use of sanitation and exclusion, and, where necessary, insecticides.

When carpet beetles threaten products in commercial warehouses or storage areas, a monitoring program using sticky traps baited with an appropriate pheromone (a chemical attractant produced by an organism to attract others of the same species) is recommended. Traps placed throughout a building can show where beetles are coming from; the traps are also useful for monitoring the effectiveness of control applications. Check traps once or twice a week. Pheromone traps can also be used to augment other control methods when used to attract adult males in small, confined areas. Sticky traps are also available without a pheromone; these traps can be placed on window sills to trap adults that fly to windows. Plain sticky traps are available in retail stores; sticky traps with a pheromone can often be purchased from local pest control operators or from distributors of pesticide supplies.

Eliminate the Source

Eliminate accumulations of lint, hair, dead insects, and other debris that serve as food for carpet beetles. Throw out badly infested items. Remove bird, rodent, bee and wasp nests, and old spider webs, which may harbor infestations. Examine cut flowers for adult beetles.

Regular and thorough cleaning of rugs, draperies, upholstered furniture, closets, and other locations where carpet beetles congregate is an important preventive and control technique. Frequent, thorough vacuuming is an effective way of removing food sources as well as carpet beetle eggs, larvae, and adults. After vacuuming infested areas, dispose of the bag promptly because it may contain eggs, larvae, or adult insects.

Protect fabrics by keeping them clean: food and perspiration stains on fabrics attract carpet beetles. Dry cleaning or thoroughly laundering items in hot water kills all stages of these insects. This is the most common method used to control fabric pests in clothing, blankets, and other washable articles.

Mounted animal specimens, such as museum specimens or game trophies, should be regularly cleaned or periodically placed in a freezer for 10 to 14 days. Inspect stored woolens, linens, and furs; air, brush, and hang them in the light on a yearly basis. If infestations are found, launder or dry clean these items to destroy carpet beetle adults, larvae, and eggs before returning them to storage. Be sure cleaned items are sealed in a protective plastic bag or other suitable container.

Some furniture, mattresses, and pillows are stuffed with hair or feathers. When carpet beetles or clothes moths get into the stuffing, they cannot be controlled simply by spraying the outside surface of the item. The best way to eliminate them is to have the infested item treated with lethal gas in a fumigation vault. This service is provided by some pest control and storage firms. Because of the potential hazards to the applicator of the fumigant, only licensed pest control operators can buy and use them. Proper fumigation gives quick, satisfactory control, and kills all stages of fabric pests. It does not prevent reinfestation, however.

Protecting Items in Storage

To properly store items that are susceptible to carpet beetles, first make sure they are pest-free and clean. Place them in an airtight container, using paper to make a layer every few inches. On the layers you can place insecticide-impregnated resin strips that are labeled for control of carpet beetles on fabrics, or you can use moth balls, flakes, or crystals, which contain naphthalene or paradichlorobenzene (PDB). Do not place these materials in direct contact with plastic buttons, hangers, or garment bags as the plastic may soften and melt into the fabric. Also, be sure to keep these materials out of reach of children and pets; do not use them where unwrapped food is stored or allow them to come into contact with food or cooking utensils.

Resin strips, which contain dichlorvos as the active ingredient, are generally more effective in protecting susceptible objects in enclosed containers and provide longer control than naphthalene or PDB. As these chemicals evaporate they produce vapors which, in sufficient concentration, will slowly kill insects. The vapors build up to the required concentration only in an airtight container—if not in an airtight container, the chemicals only repel adults; larvae already on clothes continue to feed. (Because some of the resin strips contain oil, be careful to keep them from coming in contact with the stored item.)

Generally, closets are not airtight and are opened too frequently to hold in vapors. However, seldom-used closets can be made into a suitable storage space by sealing cracks around the door with tape or fitting the door with weather-stripping. Seal cracks in walls and ceilings with putty or plastic wood. A trunk, chest, box, or garment bag makes a good storage container. Seal any holes or cracks. If the lid does not fit tightly, seal it with tape or wrap the entire container in heavy paper and seal it with tape.

Alternative methods of controlling dermestid beetles are either to freeze an infested object by placing it in a freezer (enclosed in a plastic bag) for 2 weeks at temperatures below 18°F or heating it in an oven for at least 30 minutes to temperatures above 120°F. (Before using either of these methods, consider if the object will be damaged by cold or heat.)

Questions are often raised as to the effectiveness of cedar chests and closet floors made of cedar. Some cedar contains an oil that does not affect large larvae but is able to kill small larvae. However, cedar loses this oil as it ages. Having the chest tightly constructed is more important in the long run than the type of wood used to make it.

Insecticides

Cleaning is always the best strategy; however, areas or articles that cannot be dry cleaned or laundered can be sprayed with an insecticide. Find a product that lists carpet beetles on its label and closely follow the directions. Apply insecticides as spot treatments and limit sprays to edges of floor coverings, under rugs and furniture, floors and walls of closets, shelving where susceptible fabrics are stored, cracks and crevices, and in other lint-accumulating areas. Be sure not to spray clothing and bedding.

When treating attics, wall voids, and other inaccessible places, use dust formulations. Do not let borates come in contact with objects containing natural dyes (e.g., some Oriental rugs, sheepskins, bearskins). Also, some dust formulations may adversely affect people with respiratory problems; read and follow label precautions carefully. Fumigation may be needed when infestations are extensive, although success can be limited by the ability of the fumigant to penetrate all the areas where carpet beetles hide.

On rugs and carpets, closely inspect areas beneath heavy furniture and along carpet edges for infestation. Spray both sides of infested carpet if at all possible. Apply a lighter spray to the upper surface so that the possibility of staining is reduced. If the rug pad contains animal hair or wool and has not been treated by the manufacturer, spray it also. It is preferable to wait until the rug has dried before putting any weight on it. If you are worried that expensive broadlooms or Oriental rugs may be damaged by sprays, employ an experienced pest control operator or carpet-cleaning firm.

Do not use insecticides around open flames, sparks, or electrical circuits. Do not spray them on asphalt or tile floors. Use only lightly on parquet floors. On linoleums, first spray a small inconspicuous area and let it dry to see if staining occurs.

Applying protective sprays to furs is not recommended. If you store furs at home throughout the summer, either protect them with moth crystals, flakes, or balls, or periodically shake and air them. Furs in commercial storage receive professional care and can be insured against damage.

Sometimes felts and hammers in pianos become infested and so badly damaged that the tone and action of the instrument are seriously affected. The services of a piano technician are then recommended. Synthetic felts are also available.

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REFERENCES

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Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

CLOTHES MOTHS

Integrated Pest Management in the Home

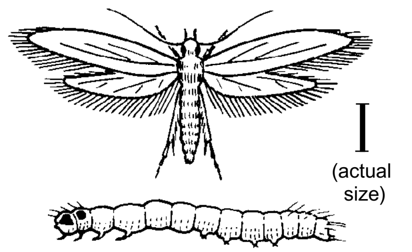

Figure 1. Webbing clothes moth.

The webbing clothes moth, *Tineola bisselliella* (Fig. 1), and the casemaking clothes moth, *Tinea pellionella* (Fig. 2), are occasional fabric pests in California. Clothes moths are weak flyers and are not attracted to lights. They tend to hide when disturbed, and for this reason, infestations of clothes moths are not usually noticed until damaged fabrics, furs, or feathers are found. Close examination of the objects reveals the presence of silken webs that are spun by the larvae.

IDENTIFICATION

The webbing clothes moth is the most common fabric moth. Adults are golden colored with reddish golden hairs on top of the head. Wings, with a span of about ½ inch, are fringed with a row of golden hairs. Because the moths are weak flyers and not attracted to lights, they are usually found very close to the infested items, such as in dark areas of closets.

Don't confuse the clothes moth with the common food- and grain-infesting moths that are frequently seen flying around the house. At rest, clothes moths are only about ¼ inch in length, whereas most food-infesting moths are about ½ inch in length. Clothes moths are relatively easy to catch when they land. When examined with a hand lens, little tufts of hair are evident on their heads—food and grain moths do not have these tufts. Clothes moths usually only fly around the immediate area of the house where the infestation is found, and their flight pattern is distinctive: they tend to flutter about rather than fly in a direct, steady manner like the food-infesting moths.

Casemaking clothes moths are similar in size and appearance to webbing clothes moths. The wings of the casemaking clothes moth are more brownish than those of the webbing clothes moth and have faint dark-colored spots. Hairs on the head are lighter colored than those of the webbing clothes moth. Larvae of both species are nearly identical, except that larvae of the casemaking clothes moth always carry a silken case with them as they feed. They never leave this silken tube, but enlarge it as they grow. They feed from either end and retreat into it when disturbed. This case takes on the coloration of the fabric eaten by the larvae.

LIFE CYCLE

Females of both species of clothes moth lay an average of 40 to 50 eggs over a period of 2 to 3 weeks and die once egg laying has been completed. Males outlive females and continue to mate during the remainder of their lives. Eggs are attached to threads of fabric with an adhesive secretion; they hatch in 4 to 10 days during warm weather. Larvae molt from 5 to 45 times, depending on indoor temperatures and type of food available. The larval period lasts from 35 days to 2½ years. Larvae are shiny white with a dark head capsule. They spin webbing as they feed and may partially enclose themselves in a webbing cover or feeding tube, depending on species. Excrement of the clothes moth may contain dyes from the cloth fibers being consumed and thus be the same color. When they are ready to pupate, larvae wander away from their food source to find crevices. With the casemaking clothes moth, pupation takes place inside the case—usually on the fabric.

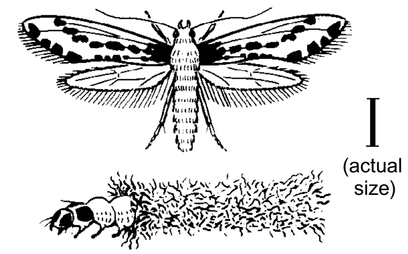

Figure 2. Casemaking clothes moth.

Pupation lasts from 8 to 10 days in summer, 3 to 4 weeks in winter. Heated buildings enable clothes moths to continue development during winter months. Generally, developmental time for the clothes moth from egg to egg is between 4 to 6 months, and there are generally two generations a year (Fig. 3).

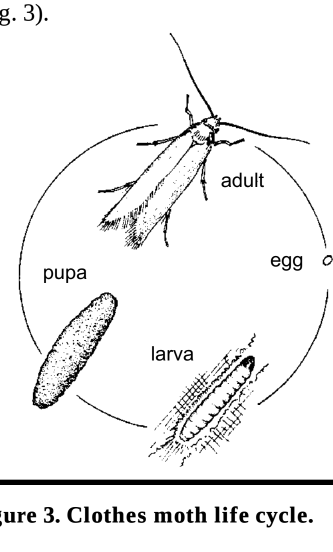

Figure 3. Clothes moth life cycle.

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DAMAGE

The larva is the damaging stage of the clothes moth. Both species feed on wool clothing, carpets, rugs, upholstered furniture, furs, stored wool, animal bristles in brushes, wool felts in pianos, and fish meal in fish food. Synthetics or fabrics such as cotton are fed on if they are blended with wool. Larvae may use cotton fibers to make their pupal cases. Damage generally appears in hidden locations such as under collars or cuffs of clothing, in crevices of upholstered furniture, and in areas of carpeting covered by furniture.

Fabrics stained by foods, perspiration, or urine are more subject to damage.

MANAGEMENT

Clothes moths can be controlled by a variety of methods, including periodic dry cleaning or laundering, proper storage, freezing, heating, or fumigating with dry ice, trapping, or using an insecticide. If humidity can be kept low inside buildings, an environment that is not suitable for clothes moth development will be created. Building construction that is free of many tiny cracks and crevices also contributes to fewer clothes moth problems. Good housekeeping practices are also important. Although most people can control clothes moth problems themselves, some infestations are best handled by a pest control applicator who has the equipment, materials, and experience necessary to deal with a difficult control job.

Preventing or Reducing Infestations

Periodically clean areas of a home that may harbor clothes moths to prevent or control infestation. Those areas include many seldom-cleaned spots, such as:

- under heavy pieces of furniture;
- along baseboards and in cracks where hair and debris accumulate;
- closets, especially those in which woolens and furs are kept; and
- heaters, the areas behind them, and vents.

The vacuum cleaner is the best tool for most of this cleaning. After using it in infested areas, dispose of the bag contents promptly; they may include eggs, larvae, or adult moths.

Clothes moths may first become established on woolen garments or scraps stored for long periods. If such articles are to be saved, they should be stored properly, or periodically hung in the sun and brushed thoroughly, especially along seams and in folds and pockets. Brushing destroys eggs and exposes larvae. Larvae are strongly repelled by light, and will fall from clothing when they cannot find protection.

Dry Cleaning and Laundering

Dry cleaning or thoroughly laundering items in hot water (temperature above 120°F for 20 to 30 minutes) kills all stages of insects. This is the most common and effective method for controlling clothes moths in clothing, blankets, and other washable articles. (Because many woolen garments should not be washed in hot water, dry cleaning may be the only suitable cleaning option.) Keeping fabrics clean also has another advantage: insects are less likely to feed on clean fabrics than on heavily soiled ones.

Protecting Items in Storage

Clothes moths often damage articles that are not stored properly. When storing susceptible items, be sure they are pest-free and clean, and place them in an airtight container. Insect repellents can be placed in the storage container. A new product made from lavender oil is available as a gel-filled sachet that can be used inside drawers and storage boxes, or hung in closets. Research studies are currently underway regarding the efficacy of this product.

Moth balls, flakes, or crystals containing naphthalene or paradichlorobenzene are also available for protecting clothes in storage. These materials are toxic and must be kept away from children and pets. They also leave an unpleasant odor on clothes and other cloth objects. If placed in contact with plastic buttons, hangers, or garment bags, they may cause the plastic to soften and melt into the fabric. As these chemicals evaporate, they produce vapors that, in sufficient concentration, will slowly kill insects. The vapors build up to the required concentration only in an airtight container. If the container is not airtight, the chemicals only weakly repel adults and any larvae already on clothes continue to feed.

Questions are often raised as to the effectiveness of cedar chests and closet floors made of cedar. Aromatic eastern red cedar, *Juniperus virginiana*, contains an oil that is able to kill small larvae, but it does not affect large larvae. After several years, however, cedar loses this quality. Having the chest tightly constructed is more important in the long run than the type of wood used to make it.

Freezing and Heating

Clothes moths can also be controlled by heating the infested object for at least 30 minutes at temperatures over 120°F, freezing the object for several days at temperatures below 18°F, or fumigating with dry ice (see "Household Furnishings").

Trapping

Trapping is a relatively easy-to-use technique that helps to both detect a webbing clothes moth infestation and to reduce it. Pheromone traps are available to trap the webbing clothes moth, but not the casemaking clothes moth. Pheromones are chemicals (in this case a sex attractant) produced by an organism to affect the behavior of other members of the same species. The sex pheromone attracts male moths into the trap where they get stuck on the sticky sides. Because the pheromone specifically attracts clothes moths, other moth species will not be attracted—conversely, webbing clothes moths will not be attracted to pheromone traps for other species such as grain-infesting moths. Pheromone traps for clothes moths are available from major hardware stores.

Place traps in closets and other areas where clothes are stored. Trapping not only allows you to detect the presence of webbing clothes moths but also provides some control because trapped males cannot mate. However, if you trap moths, you should also take other measures such as dry cleaning or laundering to protect clothes that were exposed to the moths.

Using Insecticide Sprays

If clothes moths are detected, articles that cannot be dry cleaned, laundered, heated to temperatures over 120°F, frozen, kept in cold storage, or fumigated with dry ice (see “Household Furnishings”) can be sprayed with an insecticide. Find a product that lists clothes moths on its label and follow the directions exactly. Insecticides for clothes moths usually contain pyrethrins, which provide quick knockdown of clothes moths, and most can be sprayed directly on fabrics if needed (in situations where fabrics cannot be laundered or dry cleaned). Pyrethrin insecticides do not leave persistent toxic residues, which makes them more suitable for clothes moth control in many cases than many other products.

Some insecticides have an oil base. Do not spray them on silk, rayon, or other fabrics that stain easily. Do not use them around open flames, sparks, or electrical circuits. Do not spray them on asphalt-tile floors. Use only lightly on parquet floors. On linoleums, first spray a small inconspicuous area and let it dry to see if staining occurs.

Widespread or heavy infestations often require the services of a professional pest control applicator.

Special Situations

Rugs, carpets, furs, and household furnishings require special attention for protection from clothes moths. Rugs and furnishings made entirely of synthetic fibers are not affected. This includes most wall-to-wall carpeting.

Rugs and Carpets. Closely inspect areas beneath heavy furniture and along carpet edges for infestation. Area rugs can be dry cleaned or hung out in the sun and vacuumed. The edges on wall-to-wall carpets can be pulled back so that an insecticide can be applied to both sides of infested carpets. Spray the upper surface of the carpet lightly to reduce the possibility of staining. If the rug pad contains animal hair or wool and has not been treated by the manufacturer, spray it also. It is preferable to wait until the rug has dried before putting any weight on it.

Fur. Applying protective sprays to furs is not recommended. If you store furs at home throughout the summer, protect them with moth crystals, flakes, or balls; or frequently shake and air them. Furs in commercial cold storage receive professional care and can be insured against damage.

Household Furnishings. Some furniture, mattresses, and pillows are stuffed with animal products such as hair or feathers. When clothes moths get into the stuffing, they cannot be controlled simply by spraying the outside surface of the item. The best way to eliminate them is to fumigate the item with dry ice or to have a pest control or storage firm treat the infested item with a lethal gas in a fumigation vault.

To fumigate an object with dry ice, place the item and the dry ice in a thick (4 mils) plastic bag. (Do not handle dry ice with your bare hands because it will quickly freeze your skin.) If you use a plastic bag with a 30-gallon capacity, a ½- to 1-lb piece of dry ice should be adequate. Seal the bag loosely at the top until all the dry ice has vaporized; this will allow the air to escape and keep the bag from bursting. When the dry ice is gone, tighten the seal and let the bag sit for 3 or 4 days. Proper fumigation gives quick, satisfactory control, and kills all stages of clothes moths, although it does not prevent reinfestation.

Sometimes felts and hammers in pianos become infested and so badly damaged that the tone and action of the instrument are seriously affected. The services of a piano technician are then recommended; synthetic felts are available.

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COCKROACHES

Integrated Pest Management in and around the Home

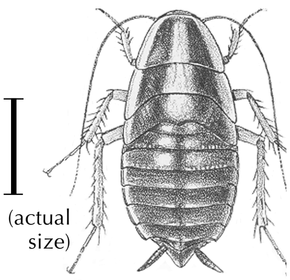

Figure 1. German cockroach nymph

There are five species of cockroaches in California that can become pests: German cockroach, brownbanded cockroach, oriental cockroach, smokybrown cockroach, and American cockroach. Of these, the one that has the greatest potential of becoming persistent and troublesome is the German cockroach, which prefers indoor locations. Oriental and American cockroaches occasionally pose problems in moist, humid areas.

PROBLEMS ASSOCIATED WITH COCKROACHES

Cockroaches may become pests in homes, restaurants, hospitals, warehouses, offices, and virtually any structure that has food preparation or storage areas. They contaminate food and eating utensils, destroy fabric and paper products, and impart stains and unpleasant odors to surfaces they contact.

Cockroaches (especially the American cockroach, which comes into contact with human excrement in sewers or with pet droppings) may transmit bacteria that cause food poisoning (*Salmonella* spp. and *Shigella* spp.). German cockroaches are believed to be capable of transmitting disease-causing organisms such as *Staphylococcus* spp., *Streptococcus* spp., hepatitis virus, and coliform bacteria. They also have been implicated in the spread of typhoid and dysentery. Some people, especially those with asthma, are sensitive to the allergens produced by these cockroaches. However, a major concern with cockroaches is that people are repulsed when they find cockroaches in their homes and kitchens.

IDENTIFICATION

Cockroaches are medium-sized to large insects in the order Dictyoptera (formerly Orthoptera). They are broad, flattened insects with long antennae and a prominent pronotum (Fig. 1). Some people confuse them with beetles, but adult cockroaches have membranous wings and lack the thick, hardened forewings or elytra of beetles. They are nocturnal and run rapidly when disturbed. Immature cockroaches (nymphs) look like adults, but are smaller and do not have wings.

Of the five common pest species, German and brownbanded cockroaches inhabit buildings, whereas the oriental, smokybrown, and American cockroaches usually live outdoors, only occasionally invading buildings. It is important to correctly identify the species involved in a cockroach infestation so that the most effective control method(s) for the species involved is chosen (Fig. 2).

German Cockroach

The German cockroach, *Blattella germanica*, is the most common indoor species, especially in multiple-family dwellings. They prefer food preparation areas, kitchens, and bathrooms because they favor warm (70° to 75°F), humid areas that are close to food and water. Severe infestations may spread to other parts of buildings. This species reproduces the fastest of the common pest cockroaches: a single female and her offspring can produce over 30,000 individuals in a year, but many succumb to cannibalism and other population pressures. Egg laying occurs more frequently during warm weather. The female carries around a light tan egg case (about 1/4 inch long) until 1 to 2 days before it hatches, when she drops it. Sometimes the egg case hatches while it is still being carried by the female. Each egg case contains about 30 young, and a female may produce a new egg case every few weeks.

Brownbanded Cockroach

The brownbanded cockroach, *Supella longipalpa,* is not as common as the German cockroach in California and accounts for only about 1% of all indoor infestations. This species seeks out areas that are very warm most of the time, preferring temperatures of about 80°F, about 5° to 10°F warmer than what German cockroaches prefer. Favorite locations include near the warm electrical components of appliances such as radios, televisions, and refrigerators. Brownbanded cockroaches prefer starchy food (e.g., glue on stamps and envelopes), are often found in offices and other places where paper is stored, and are more common in apartments or homes that are not air conditioned. They also infest animal-rearing facilities, kitchens, and hospitals. Adult males sometimes fly when disturbed, but females do not fly. Females glue light brown egg cases, which are about 1/4 inch long, to ceilings, beneath furniture, or in closets or other dark places where eggs incubate for several weeks

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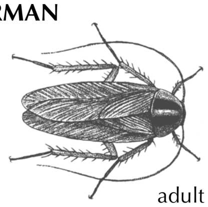
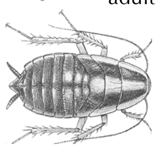
FIGURE 2. Identifying features of the different species of pest cockroaches

GERMAN

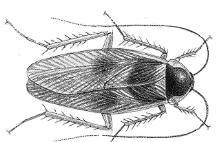

adult

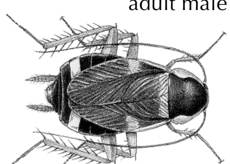

nymph

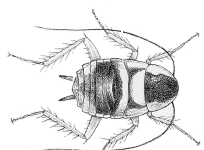
Adult: 0.5 inch; light brown, two dark stripes on pronotum

Preferred location: kitchens, bathrooms, food preparation and storage areas

BROWNBANDED


adult male

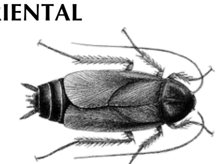

adult female

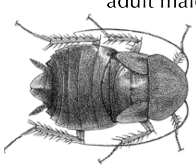

nymph

Adult: 0.5 inch; males are golden tan; females are darker brown; both have light-colored bands on abdomen, wings, and sides of pronotum

Preferred location: warm areas indoors

ORIENTAL

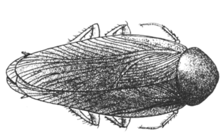

adult male


adult female

Adult: 1.25 inch; almost black; male, wings are shorter than body; female, wings are rudimentary

Preferred location: damp, dark places—woodpiles, garages, basements, and in drains

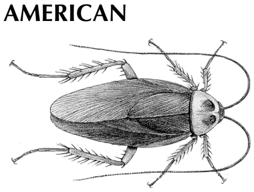
SMOKYBROWN


adult

Adult: 0.5 inch; dark brown to mahogany; almost black pronotum
Nymph: banded pattern on antennae

Preferred location: trees, shrubs, vegetation

AMERICAN


adult

Adult: 2 inches; reddish brown; large body, edges of pronotum are light colored

Preferred location: sewers, steam tunnels, animal-rearing facilities

before hatching. Each female and her offspring are capable of producing over 600 cockroaches in one year.

Oriental Cockroach

The oriental cockroach, *Blatta orientalis,* is sometimes referred to as a waterbug or waterbeetle. It lives in dark, damp places like indoor and outdoor drains, water control boxes, woodpiles, basements, garages, trash cans, and damp areas under houses. It is most likely to occur in single-family dwellings that are surrounded by vegetation. It is also common in ivy, ground cover, and outside locations where people feed pets. They prefer cooler temperatures than the other species do, and populations of this species often build to large numbers in masonry enclosures such as water meter boxes. At night, oriental cockroaches may migrate into buildings in search of food. They usually remain on the ground floor of buildings and move more slowly than the other species. Oriental cockroaches do not fly and are unable to climb smooth vertical surfaces; consequently they are commonly found trapped in porcelain sinks or tubs. Females deposit dark red-brown egg cases, which are about 3/8 inch long, in debris or food located in sheltered places. Each female and her offspring can produce nearly 200 cockroaches in one year. Development from a newly emerged nymph to adult can take from 1 to 2 years or more.

Smokybrown Cockroach

The smokybrown cockroach, *Periplaneta fuliginosa,* is usually found in decorative plantings and planter boxes, woodpiles, garages, and water meter boxes; it may occasionally inhabit municipal sewers. They sometimes invade homes, taking refuge in areas such as the attic. Nymphs are dark brown and have white segments at the end of their antennae and across their backs. Smokybrown cockroaches prefer the upper parts of buildings; they also may live under shingles or siding and sometimes get into trees, shrubs, and other vegetation during summer months. Females carry the dark brown to black egg case, which measures about 3/8 inch long, for about 1 day before dropping it; eggs can hatch in as soon as 24 days after being laid or as long as 70 days after laying, depending on temperature. About 40 to 45 nymphs hatch from a single egg case.

American Cockroach

The American cockroach, *Periplaneta americana,* prefers warm and humid environments, usually with temperatures in excess of 82°F. Under the right conditions, they readily live outdoors and are common pests in zoos and animal-rearing facilities. They are also common in sewers, steam tunnels, and masonry storm drains. Occasionally they forage from sewers and other areas into the ground floor of buildings. Adult females carry the egg cases around for about 6 days and then cement them to a protected surface where they incubate for about 2 months or longer. The egg cases, which are about 3/8 inch long, are brown when laid but turn black in 1 to 2 days. Each egg capsule contains about 12 young; a female and her offspring can produce over 800 cockroaches in one year.

LIFE CYCLE

An adult female cockroach produces an egg capsule, called an ootheca, which it carries around protruding from the tip of the abdomen. The German cockroach carries the ootheca for most of the 30-day incubation period and then drops it about the time the eggs hatch; the other four species carry it for only about a day before depositing it in a suitable location where it incubates for weeks or months. Young or immature cockroaches undergo gradual metamorphosis, which means they resemble adults and have similar feeding habits, but they do not have fully developed wings and are not reproductively active. Immediately after molting, cockroaches are white, but their outer covering darkens as it hardens, usually within hours.

Cockroaches are nocturnal. They hide in dark, warm areas, especially narrow spaces where surfaces touch them on both sides. Adult German cockroaches can hide in a crack 1/16 inch or 1.6 mm wide. Immature cockroaches tend to stay in even smaller cracks where they are well protected. Cockroaches tend to aggregate in corners and generally travel along the edges of walls or other surfaces.

MANAGEMENT

Managing cockroaches is not easy. You must first determine where the roaches are located. The more harborages you locate and treat, the more successful your control program will be. Remember that cockroaches are tropical and like warm hiding places with access to water. Some locations will be difficult to get to. If cockroaches have access to food, baits will have limited effect. Sprays alone will not eliminate cockroaches. An approach that integrates several strategies is required.

If you know the species of cockroach, you will be better able to determine where the source of infestation is and where to place traps, baits, or insecticides. Note locations of suspected infestation and concentrate control measures in these areas. The keys to controlling cockroaches are sanitation and exclusion: cockroaches will continue to reinvade as long as a habitat is suitable to them (i.e., food, water, and shelter are available), so the conditions that attracted and favored the infestation must be changed. In addition to sanitation and exclusion, baits and sticky traps can be effective against most species of cockroaches. As a last resort, sprays or dusts that are registered for use on cockroaches may temporarily suppress populations, but they do not provide long-term solutions. Commercially available devices that emit sound to repel cockroaches are not effective.

Monitoring Cockroaches

Traps offer the best way to monitor cockroach populations. By placing traps in several locations and inspecting them regularly, you can identify the areas of most severe infestation and know where to concentrate control efforts. Traps also can be very helpful in evaluating the effectiveness of control strategies.

Traps can be purchased or made. Most commercially available cockroach traps are open-ended and contain an attractant substance along with a sticky material that lines the inside. An alternative is to make a cockroach trap from a quart-sized can. The inside top of the can is coated with a petroleum jelly to prevent the roaches from escaping, and a slice of white bread is placed in the can as bait.

To be effective, traps must be placed where cockroaches are likely to encounter them when foraging. The best places are along the edges of floors and walls and close to sites where cockroaches are numerous; these sites can be determined by accumulations of fecal matter (e.g., dark spots or smears), cast skins, egg cases, and live or dead cockroaches. In the kitchen put traps against walls behind the stove and the refrigerator and in cabinets. Check the traps daily for several days until it is apparent where the greatest number of roaches are caught; usually this is within the first 24 hours of placing a trap—after that cockroaches may become wary of the trap. Trapped cockroaches may be destroyed with hot, soapy water.

You can also monitor a cockroach population at night using a flashlight to inspect cracks, underneath counters, around water heaters, and in other dark locations. Look for live and dead cockroaches, cast skins, egg capsules, and droppings, all of which aid in identification and are evidence of an infestation.

Sticky Traps with Pheromones

Continuous trapping, especially of slow-developing species such as the oriental cockroach, may be helpful. Trapping by itself has not been shown to be effective in controlling German or brownbanded cockroaches because these species have such a high reproductive rate. A recent development in the use of sticky traps, however, has been the addition of an aggregation pheromone attractant. With this development, sticky traps have become more useful as a control tool for German cockroaches. An additional benefit of pheromone sticky traps is that the bodies of trapped roaches are removed with the traps. Dead roaches contain proteins that can cause asthma symptoms when they are inhaled by susceptible individuals, so the removal of dead cockroaches may be beneficial in certain situations. Intensive trapping may provide a reduction in German cockroach populations but the number of traps and their placement are critical: follow the manufacturer's recommendations.

Sanitation

Cockroaches thrive where food and water are available to them. Even tiny amounts of crumbs or liquids caught between cracks provide a food source. Important sanitation measures include the following:

- Store food in insect-proof containers such as glass jars or sealable plastic containers.

- Keep garbage and trash in containers with tight-fitting lids. Remove trash, newspapers, magazines, piles of paper bags, rags, boxes, and other items that provide hiding places and harborage.

- Eliminate plumbing leaks and correct other sources of free moisture. Increase ventilation where condensation is a problem.

- Vacuum cracks and crevices to remove food and debris. Be sure surfaces where food or beverages have been spilled are cleaned up immediately. Vacuuming also removes cockroaches, shed skins, and egg capsules. Removing cockroaches reduces their numbers and slows development. Vacuumed cockroaches and debris should be destroyed. Because bits of cuticle and droppings may be allergenic, it is recommended that the vacuum cleaner have HEPA (high efficiency particulate absorber) or triple filters.

- Trim shrubbery around buildings to increase light and air circulation, especially near vents, and eliminate ivy or other dense ground covers near the house, as these may harbor cockroaches.

- Remove trash and stored items such as stacks of lumber or firewood that provide hiding places for cockroaches from around the outside of buildings.

Exclusion and Removal of Hiding Places

During the day cockroaches hide around water heaters, in cupboard cracks, stoves, crawl spaces, outdoor vegetation, and many other locations. They invade kitchens and other areas at night. Limiting hiding areas or avenues of access to living areas is an essential part of an effective management strategy. False-bottom cupboards, hollow walls, and similar areas are common cockroach refuges. Prevent access to the inside of buildings through cracks, conduits, under doors, or through other structural flaws. If it is not practical to remedy these problem areas, treat them with boric acid powder.

Take the following measures if roaches are migrating into a building from outdoors or other areas of the building:

- Seal cracks and other openings to the outside.

- Look for other methods of entry, such as from items being brought into the building, especially appliances, furniture, and items that were recently in storage.

- Look for oothecae glued to undersides of furniture, in refrigerator and other appliance motors, boxes, and other items. Remove and destroy any that are located.

- Locate and seal cracks inside the treatment area where cockroaches can hide.

Chemical Control

Insecticides are most effective in controlling cockroaches when combined with sanitation and exclusion practices that limit the cockroach's ability to establish or reinvade; chemical control alone will not solve the problem. If insecticides are used, they must always be used with extreme care. Indoor chemical control is warranted only if the cockroach population is established but not for an incidental intruder or two.

Dusts. One effective dust for control of cockroaches is boric acid powder, which is a contact poison. It is the least repellent of all the insecticides for cockroach control, and if it remains dry and undisturbed, it provides control for a very long time. Because it has a positive electrostatic charge, the dust clings to the body of a cockroach as it walks through a treated area and the cockroach ingests small amounts when it grooms itself. Because boric acid powder is fairly slow acting, it may take 7 days or more to have a significant effect on a cockroach population. Because of its toxicity to plants, boric acid is not recommended for outdoor use.

Blow dust into cracks and crevices or lightly spread it in areas where visible residues are not a problem and where people will not contact it. Remove kick panels on refrigerators and stoves and apply a light film of dust throughout the entire area underneath these appliances. A thin film of dust is more effective than a thick layer. Holes that are the same size as the tip of a puff-type applicator can be drilled into the top of kick panels beneath cabinets and powder may be applied through the holes to these areas as well as under the sink, in the dead space between the sink and wall, and around utility pipes. Also treat along the back edges and in corners of shelves in cabinets, cupboards, pantries, and closets.

Boric acid powder does not decompose and is effective for as long as it is left in place, if it remains dry. Formulated as an insecticide, boric acid dusts usually contain about 1% of an additive that prevents the powder from caking and improves dusting properties. If it gets wet and then dries and cakes, it loses its electrostatic charge and will not be picked up readily by the cockroach. If this occurs, reapply powder to these areas.

Baits. Baits are formulated as pastes, gels, granules, and dusts. The most popular use of baits in homes is within bait stations, which are small plastic or cardboard units that contain an attractive food base along with an insecticide. Bait gels are placed in small dabs in cracks and crevices where cockroaches will find it. The advantage of bait stations is that insecticides can be confined to a small area rather than being dispersed and they are relatively child resistant. Baits in plastic containers also remain effective for many months whereas the bait gels dehydrate in about 3 days when left in the open air. But while they are fresh, bait gels are very effective when placed in locations where they will be found by cockroaches. To remain effective, however, the gels need to be reapplied frequently.

Most insecticides used in baits are slow acting; cockroaches quickly learn to avoid fast-acting ones. Consequently an effective bait program does not give immediate results, but may take 7 days or longer. Baits can be quite effective for long-term control of cockroaches unless the cockroaches have other food sources available to them.

Baits do not control all cockroaches equally. Female cockroaches with egg cases do very little feeding and avoid open spaces; consequently they are less likely to be immediately affected by a bait.

Commercial baits available (see Table 1) contain abamectin, boric acid, fipronil, hydramethylnon, or sulfluramid mixed with a food base. Sulfluramid is not as effective as the other materials because it is somewhat volatile and there has been some development of resistance to it.

As with sticky traps, baits do not attract cockroaches so place them near hiding spaces or where roaches are likely to encounter them when foraging. When placed next to a sticky trap that contains an attractant pheromone, bait consumption by the roaches is reported to increase. Bait stations can also be placed next to fecal specks and droppings of cockroaches, which contain a natural aggregation pheromone. Look for these fecal specks and droppings under kitchen counters, behind kitchen drawers, and in the back of cabinets.

Insect Growth Regulators. The insect growth regulator (IGR) hydroprene prevents immature cockroaches from becoming sexually mature. It also has the added advantage of stimulating cockroaches to feed. When placed next to a bait it can increase bait consumption. Under normal circumstances an adult female cockroach carrying an egg case doesn't feed much, but exposure to an IGR will induce her to feed.

TABLE 1. Baits Currently Available for Use in Homes

Active ingredient	Brand name	Formulation	Where to get product
abamectin	Avert	gel, powder	pest control company
abamectin plus hydroprene	Raid Max Plus Egg Stoppers	bait station	retail stores
boric acid	Stapleton's Magentic	paste	Blue Diamond Phone: (800) 237-5705
	Niban and others	granules	pest control company
fipronil	Maxforce	bait station	pest control supply store
	Maxforce	gel	pest control supply store
hydramethylnon	Combat	bait station	retail stores
	Combat	granules	retail stores
	Maxforce	gel	pest control supply store
	Siege	gel	pest control company

Sprays and Aerosols. Applying low-residual insecticides to get a quick knockdown of cockroaches in an infested area can provide immediate relief from a cockroach infestation but generally does not give long-term control. Common home use insecticides include combinations of pyrethrin and piperonyl butoxide or pyrethroids such as cyfluthrin, cypermethrin, and permethrin. The safest application method for home users is the crack-and-crevice spray used in combination with sanitation and exclusion. Avoid the use of insecticide aerosol sprays, bombs, or foggers, as these will just disperse the cockroaches and may actually increase problems.

The faster the knockdown activity of an insecticide, the quicker cockroaches learn to avoid it. Cockroaches are repelled by deposits of residual insecticides such as synergized pyrethrins and emulsifiable concentrate formulations of pyrethroids such as cyfluthrin, cypermethrin, and permethrin. Wettable powder formulations are generally less repellent and more effective on a wide range of surfaces; however, they may be unsightly.

It should be noted that many cockroach populations, especially the German cockroach, have developed resistance (or tolerance) to many insecticides used for their control. Resistance has been documented with allethrin, chlorpyrifos, cyfluthrin, cypermethin, fenvalerate, and others. Do not expect instant results from an insecticide spray application, but if the cockroaches seem to be unaffected the following day, a different material or strategy may be required.

Under extreme circumstances when professional pest control services are warranted to alleviate a persistent cockroach infestation, everything should be removed from kitchen drawers, cabinets, cupboards, and closets and stacked in out-of-the-way places and covered to prevent their contamination with the spray. This also allows for thorough coverage of surfaces. Do not replace these items until the spray is dry. Treated surfaces should not be washed or the effectiveness of the treatment will be reduced.

Always combine the use of insecticides with sanitation and exclusion, apply dusts or use bait stations, alternate the types of active ingredients and formulations that are used, or use insecticides, such as boric acid, that do not repel cockroaches or for which cockroaches have not developed resistance.

If you wish to avoid sprays and aerosols completely, a thorough vacuuming with a HEPA or triple filter vacuum cleaner followed by the use of boric acid dust in cracks and crevices and a baiting program can effectively control severe infestations.

Follow-Up

After a cockroach control program has been started, evaluate the effectiveness of the methods that are being used. Use traps or visual inspections to help determine if further treatment is necessary.

If populations persist, reevaluate the situation. Look for other sources of infestations, make sure that all possible entryways are blocked, be certain that food and water sources are eliminated as much as possible, and continue sealing and eliminating hiding places.

When cockroach populations are under control, continue monitoring with traps on a regular basis to make sure reinfestation is not taking place. Maintain sanitation and exclusion techniques to avoid encouraging a new infestation. If severe reinfestations continue to recur, consider having the infested areas modified or remodeled to reduce the amount of suitable habitat for cockroaches.

REFERENCES

Ebeling, W. 1974. *Boric Acid Powder for Cockroach Control.* Oakland: Univ. Calif. Div. Agric. Nat. Res. One-Sheet Answers #206.

Quarles, W. 1998. Pheromones and nontoxic cockroach control. *IPM Practitioner,* Vol. XX (5/6):1-7.

Rust, M. K., J. M. Owens, and D. A. Reierson, eds. 1995. *Understanding and Controlling the German Cockroach*. New York: Oxford University Press.

Slater, A. J. 1978. *Controlling Household Cockroaches*. Oakland: Univ. Calif. Div. Agric. Nat. Res. Leaflet 21035.

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits and/or vegetables ready to be picked.

Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse the containers. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Do not pour down sink or toilet. Consult your county agricultural commissioner for correct ways of disposing of excess pesticides. Never burn pesticide containers.

FLEAS

Integrated Pest Management In and Around the Home

Cat fleas *(Ctenocephalides felis)* are frequently encountered in homes and are common pests on domestic cats and dogs. Dog fleas *(Ctenocephalides canis)* look like cat fleas, but are rare in California. Sticktight fleas *(Echidnophaga gallinacea)* can become a problem when pets frequent areas near poultry. Female sticktight fleas firmly attach themselves around the ears and eyes of their host. Fleas on either cats or dogs in California are most likely cat fleas.

IDENTIFICATION

Adult fleas (Fig. 1) are very small insects (up to 1/8 inch), so it is difficult to see a number of the characteristics used to describe them. These reddish brown to black, wingless insects are compressed from side to side so that they look like they are walking "on edge." They have piercing-sucking mouthparts through which they obtain blood meals from their hosts. Flea larvae are tiny (up to 3/16 inch long), hairy, and wormlike with a distinct, brownish head, but no eyes or legs.

LIFE CYCLE

Female cat fleas remain on the host (unlike most other fleas) and lay about 20 to 30 eggs per day on the animal. Cat flea eggs are pearly white, oval, and about 1/32 inch long. The eggs are smooth; they readily fall from the pet and land on surfaces like bedding and carpeting in the animal's environment. They hatch in about 2 days. The whitish, wormlike larvae (Fig. 2) feed on dried blood and excrement produced by adult fleas feeding on the pet. Larval development is normally restricted to protected places where there is at least 75% relative humidity. They feed and crawl around for 5 to 15 days at 70° to 90°F before they build small silken cocoons in which they develop into adult fleas (pupate). The pupae are usually covered with local debris for visual camouflage. Flea larvae develop more quickly at higher temperatures. At cool temperatures, fully formed fleas may remain in their cocoons for up to 12 months. Warm temperatures and mechanical pressure, caused by walking on the carpet, vacuuming, and so on, stimulate emergence from the cocoon. At room temperatures, the entire life cycle may be completed in about 18 days. An adult cat flea generally lives about 30 to 40 days on the host; it is the only stage that feeds on blood. Fleas may be found on pets throughout the year, but numbers tend to increase dramatically during spring and early summer.

PROBLEMS ASSOCIATED WITH FLEAS

The cat flea is suspected of transmitting murine typhus to humans, but its primary importance is in its annoyance to people and pets. Cat fleas readily try to feed on almost any warm-blooded animal. Some people are bothered by the sensation of fleas walking on their skin, but bites are the major nuisance. Bites tend to be concentrated on the lower legs but can also occur on other parts of the body. The bite consists of a small, central red spot surrounded by a red halo, usually without excessive swelling. Flea bites usually cause minor itching but may become increasingly irritating to people with sensitive or reactive skin. Some people and pets suffer from flea bite allergic dermatitis, characterized by intense itching, hair

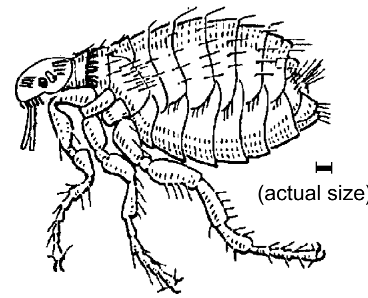

Figure 1. Adult flea.

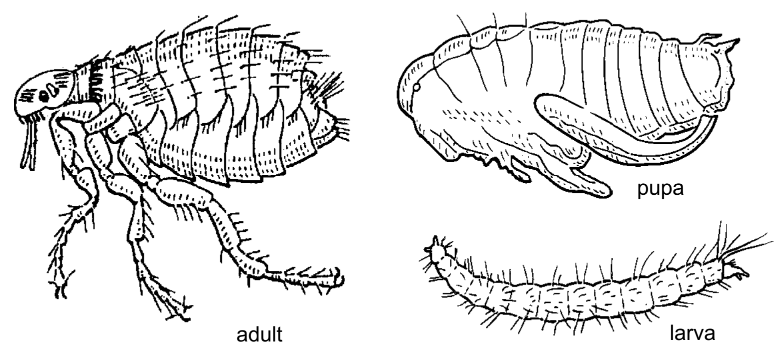

Figure 2. Life stages of the flea (egg not shown).

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loss, reddening of the skin, and secondary infection. Just one bite may initiate an allergic reaction, and itching may persist up to 5 days after the bite. Cat fleas may also serve as intermediary hosts of dog tapeworms. Cats or dogs may acquire this intestinal parasite while grooming themselves by ingesting adult fleas that contain a cyst of the tapeworm.

MANAGEMENT

The best approach to managing fleas is prevention. New, safer, and more effective products aimed at controlling fleas on the pet have made flea management without pesticide sprays feasible in many situations. Management of fleas on the pet must be accompanied by regular, thorough cleaning of pet resting areas indoors and outside. Once fleas infest a home, control will require a vigilant program that includes cleaning and treating infested areas indoors, eliminating fleas on pets, and cleaning up and possibly treating shaded outdoor locations where pets rest.

On the Pet

Several types of products are available to control fleas on dogs and cats. The most effective and safest products inhibit normal growth or reproduction of fleas. Use of these products must be supplemented with good housekeeping in areas where the pet rests. Contact your veterinarian for advice and assistance in selecting the best flea control product for your situation.

Preferred On-pet Flea Treatment Products. New product innovations have made it possible to effectively, conveniently, and safely prevent flea populations from building up on pets. These products are more effective and safer than the traditional insecticide dusts and sprays, which until a few years ago were the only choices for pet owners. The new products contain insect growth regulators (IGRs) such as methoprene (Precor) or pyriproxyfen (Nylar), and insect development inhibitors (IDIs) such as lufenuron (Program). The IGRs are available as flea collars or spot-ons applied to one or two places on the pet's coat. IDIs come formulated as a systemic treatment that must be administered orally and are available from veterinarians. These products work by either preventing the larvae from turning into adults (IGRs), or the eggs from hatching (IDIs), and are virtually nontoxic to pets and people. Two other new types of safe and effective chemicals are fipronil and imidacloprid, which are used as spot-ons. If properly applied before flea season begins and reapplied as necessary, any of these products can prevent a flea infestation.

Spot-on Formulations. Imidacloprid (Advantage) and fipronil (Front-Line) are available from veterinarians and are applied to the animal's skin; a single application provides flea control for 1 to 3 months. These spray and spot-on formulations are much easier to use than baths and are more acceptable to the animal. A few drops of the spot-on formula applied to the animal's shoulder blades move through the animal's coat, providing whole-body treatment. Both materials kill adult fleas within hours of the flea jumping on the animal. Also, these compounds have lower mammalian toxicity than traditionally used flea control products containing carbamates and organophosphates and are safer to use on pets. Generally the spot-on formulations can withstand bathing; check the label for specific instructions.

Systemic Oral Treatments. Several flea control products are internal medications that are administered on a regular basis in the form of a pill or food additive. Older types of medications contained insecticidal materials, mostly organophosphates, that were transported to all skin areas through the animal's blood. Newer products contain insect development inhibitors that do not have the toxicity of the older materials and are much safer to use. The insect development inhibitor lufenuron (Program) can be given as a pill (dogs) or as a food additive (cats) once a month to suppress flea populations. It can also be administered as an injection every 6 months. While this compound does not kill adult fleas, it does prevent flea reproduction. If its use is initiated early in the year before flea populations begin to build, it can prevent the establishment of a flea population in the home, though an occasional adult flea may be sighted on the animal.

Flea Collars. Flea collars containing the insect growth regulators methoprene and pyriproxyfen are virtually nontoxic to pets and humans and can be used on both cats and dogs. The growth regulator is released by the collar and distributed throughout the coat of the pet. Adult fleas coming in contact with the growth regulator absorb it into their bodies where it accumulates in their reproductive organs. Eggs laid by the adult female do not hatch. Flea collars may contain the insect growth regulator as the sole active ingredient or it may be combined with an insecticide. If the collar contains only the insect growth regulator, use another treatment, such as a spot-on product, to control adult fleas if necessary. Flea collars containing methoprene are effective for 4 to 6 months on dogs and up to a year on cats.

Traditional Insecticide Products. Until recently, pet owners had to rely on products containing conventional insecticides (pyrethrins, permethrin, d-limonene, chlorpyrifos, or carbaryl) to control fleas on their pets. These products were formulated as soaps, shampoos, powders, dusts, spray-on liquids, and dips. Although many of these products are still available, they are not as effective or as safe to use as the products listed in the section above titled "Preferred On-pet Flea Treatment Products." Some products are not safe for some pets, such as permethrin products on some cats, and small children and infants should be kept away from animals treated with any of these materials for at least a day or two.

Nonchemical Treatments. Special combs are available that help remove adult fleas from the coat of a short-haired pet. Removing fleas may provide comfort to the animal and reduce flea breeding. Combing pets at regular intervals is also a good way to monitor the flea population and help you decide when other control measures may be necessary.

Studies have shown that neither Vitamin B_1 (thiamine hydrochloride) supplements nor brewer's yeast prevents fleas from feeding; also, herbal collars and ultrasonic devices are not effective flea repellents.

Indoors

Controlling cat fleas in buildings requires a variety of approaches. Before starting a control program, look through each room in the building to determine areas where larval development occurs. Flea populations are highest in places where dogs or cats regularly sleep. Flea larvae are not usually found in areas of heavy pedestrian traffic or locations that receive exposure to sunlight; they are likely to be present in areas where adult fleas have left dried blood and feces.

Sanitation. Thoroughly and regularly clean areas where adult fleas, flea larvae, and flea eggs are found. Vacuum floors, rugs, carpets, upholstered furniture, and crevices around baseboards and cabinets daily or every other day to remove flea eggs, larvae, adults, and food sources. Vacuuming is very effective in picking up adults and stimulating preemerged adults to leave their cocoons. Flea eggs can survive and develop inside vacuum bags and adults may be able to escape to the outside, so immediately destroy bags by burning or by sealing them in a plastic trash bag and placing them in a covered trash container. Launder pet bedding in hot, soapy water at least once a week.

Thoroughly clean items brought into the building, such as used carpets or upholstered furniture, to prevent these from being a source of flea infestation.

Insecticides. Several insecticides are registered for controlling fleas indoors. Sprays are only needed when you detect an infestation in your home. The most effective products contain one of the insect growth regulators: methoprene or pyriproxyfen. Fleas are known to build up resistance to insecticides, so always supplement sprays with other methods of control such as thorough, frequent vacuuming.

Use a hand sprayer or aerosol to apply insecticides directly to infested areas of carpets and furniture. Total release aerosols ("room foggers") do not provide the coverage and long-term effectiveness of direct sprays unless they contain an insect growth regulator. Treatments with insecticides other than IGRs often fail to control flea larvae because the treatment material fails to contact them at the base of carpet fibers where they develop.

Spray carpets, pet sleeping areas, carpeted areas beneath furniture, baseboards, window sills, and other areas harboring adults or larvae. Use an insect growth regulator (methoprene or pyriproxyfen) that specifically targets the larvae and has a long residual life. As soon as the spray dries, vacuum to remove additional fleas that emerge from the pupal stage in carpets and upholstery. Fleas will continue to emerge for about 2 weeks after treatment because pupae are not killed by sprays. Continue to vacuum and do not treat again for at least several weeks. Always seal and discard vacuum bags so fleas don't escape.

Outdoors

Outdoor flea populations are most prevalent in coastal localities and other places with moderate daytime temperatures and fairly high humidities. In Central Valley locations, populations can become very numerous in shaded and protected areas such as sheltered animal enclosures, crawl spaces where pets may sleep, or vegetated areas adjacent to buildings. If an infested outdoor location is not treated, the flea problem may reoccur if pets are reinfested. However, treatment of the pet with any of the preferred pet treatment products listed above will normally prevent reinfestation.

Outdoor sprays are not necessary unless you detect significant numbers of adult fleas. One way to do this is to walk around pet resting areas wearing white socks pulled up to the knee. If fleas are present, they will jump onto socks and be readily visible.

The best products for elimination of fleas outdoors are formulations that contain a knockdown material such as

Handling a Flea Emergency

If your home is heavily infested with fleas, take these steps to get the situation under control.

Inside the Home

1. Locate heavily infested areas and concentrate efforts on these areas.
2. Wash throw rugs and the pet's bedding.
3. Vacuum upholstered furniture. Remove and vacuum under cushions and in cracks and crevices of furniture.
4. Vacuum carpets, especially beneath furniture and in areas frequented by pets. Use a hand sprayer to treat all carpets with an insecticide that contains an insect growth regulator.
5. Allow carpet to dry and vacuum a second time to remove additional fleas that were induced to emerge.
6. Continue to vacuum for 10 days to 2 weeks to kill adult fleas that continue to emerge from pupal cocoons.

On the Pet

1. Use a spot-on treatment, which can be purchased in pet stores or from vets, or a systemic oral treatment, which is available from vets only.

Outside the Home

1. Sprays are only necessary outdoors if you detect lots of fleas.
2. Locate and remove debris in heavily infested areas, especially where pets rest. Concentrate treatment in these areas with a spray containing a residual insecticide and the insect growth regulator pyriproxyfen. Open areas to sunlight by removing low hanging vegetation.

pyrethrin or permethrin plus an insect growth regulator (pyriproxyfen) to inhibit larval maturation. Avoid products containing diazinon or chlorpyrifos as these materials pollute waterways when they are washed into storm drains by rain, hosing, or irrigation.

Apply sprays directly in locations where pets rest and sleep such as doghouse and kennel areas, under decks, and next to the foundation. It is seldom necessary to treat the whole yard or lawn areas. Flea larvae are unlikely to survive in areas with sunlight exposure or substantial foot traffic.

Regular lawn watering will help destroy larvae and prevent development of excessive flea populations. If possible, open pet sleeping areas to sunlight by removing low-hanging vegetation.

SUGGESTED READING

Dryden, M. W., and M. K. Rust. 1994. The cat flea: Biology, ecology and control. *Veterinary Parasitology* 52:1-19.

Hinkle, N. C., M. K. Rust, and D. A. Reierson. 1997. Biorational approaches to flea (Siphonaptera: Pulicidae) suppression. *J. Agric. Entomol.* 14(3):309-321.

Potter, M. 1997. *Ridding Your Home of Fleas.* Lexington: University of Kentucky. *(http://www.uky.edu/Agriculture/Entomology/entfacts/struc/ef602.htm;* and *http://www.uky. edu/Agriculture/Entomology/entfacts/struc/ef628.htm)*

Rust, M. K., and M. W. Dryden. 1997. The biology, ecology, and management of the cat flea. *Annu. Rev. Entomol.* 42:451-473.

For more information contact the University of California Cooperative Extension or agricultural commissionerÕs office in your county. See your phone book for addresses and phone numbers.

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Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

FLIES

Integrated Pest Management In and Around the Home

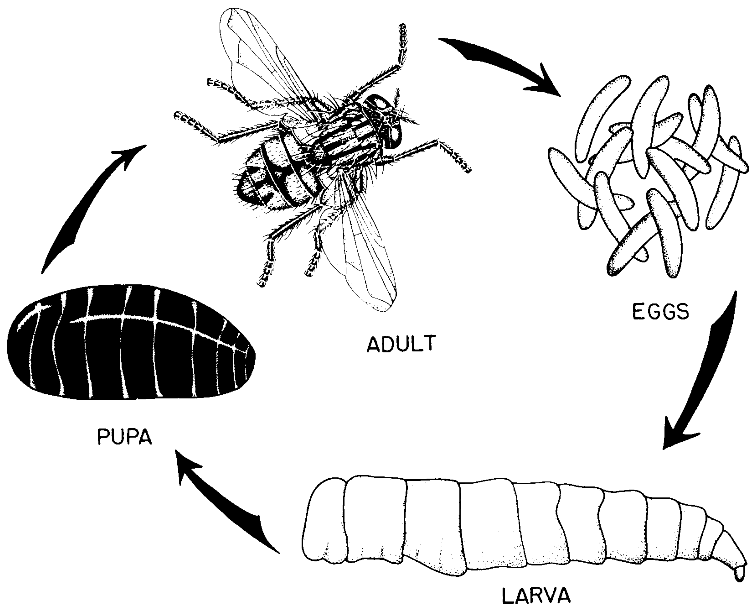

Figure 1. Life cycle of the fly.

Of the thousands of species of flies, only a few are common pests in and around the home. Four of the more frequent pests are the house fly (*Musca domestica*), the face fly (*Musca autumnalis)*, the stable fly (*Stomoxys calcitrans)*, and the little house fly (*Fannia* spp.). These pests breed in filthy locations from which they can contaminate food and transmit diseases; stable flies feed on mammalian blood.

All flies undergo complete metamorphosis with egg, larva, pupa, and adult stages in their development (Fig. 1). The female fly deposits her eggs in moist organic material where the larvae, or "maggots," complete their development. When the maggots have completed their development and are ready to undergo the next step in their metamorphosis, they convert their last larval skin into the puparium, a hardened shell within which the pupa develops. The pupa then transforms into the adult fly, which pops off the end of the puparium and emerges. By pumping body fluids into the veins, the fly unfolds and expands its wings, allowing them to dry and harden before it can fly. Under optimal conditions the egg-to-adult development may require as little as 7 to 10 days. Once the female fly has mated, she can lay several batches of eggs, typically containing over 100 eggs each.

While humans are most commonly bothered by the adult stage, the larval stage should be the prime target for control. Elimination of larval habitat is the preferred method of pest fly suppression. By removing the material in which larvae develop, the life cycle of the fly can be broken, preventing subsequent production of the adult pests. While chemical pesticides may be necessary for suppressing adult fly populations in some situations, they are not a substitute for prevention through the elimination of breeding sites. Because flies can quickly develop resistance to insecticides in a few generations, use them only as a last resort to obtain immediate control.

HOUSE FLY

Identification and Life Cycle

The house fly *(Musca domestica*) is a cosmopolitan companion of humans and domestic animals. House flies are less than one-half inch in length. They are gray, with four dark stripes down the dorsum of the thorax (Fig. 2). House flies have sponging mouthparts and can ingest only liquids. However, they can eat solid food (e.g., sugar, flour, pollen) by first liquefying it with their saliva.

Under favorable conditions the house fly can reproduce prodigiously because of its short generation time and

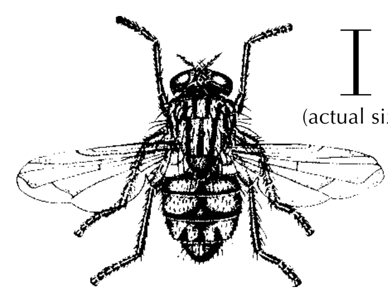

Figure 2. House fly.

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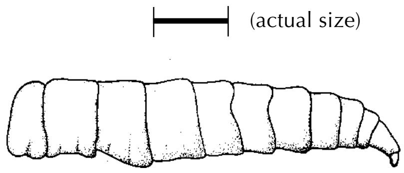

Figure 3. House fly larva.

the large number of eggs produced by each female—several batches of about 150 eggs. Eggs are laid in warm, moist, organic materials such as manure, garbage, lawn clippings, decaying vegetables and fruits, or soils contaminated with any of these materials. Under good conditions the eggs hatch in less than a day. The cream-colored larvae can then complete development within a week. Larvae of the house fly have a blunt posterior end and taper to a point at the head end (Fig. 3). Larvae seek drier areas to pupate. Pupation lasts 4 to 5 days and a generation can be completed in less than 2 weeks; during the summer 10 to 12 generations can develop.

Damage

Because they have sponging mouthparts, house flies cannot bite; however, they have been demonstrated to mechanically transmit the causative agents of diarrhea, cholera, yaws, dysentery, and eye infections. Flies are also implicated as mechanical vectors of *Shigella* and *Salmonella*, the latter being a pathogen responsible for food poisoning.

Management of House Flies

Most measures to control house flies are nonchemical. In almost all cases where flies are seen inside a building they have entered from the outside. Therefore, mechanical control remains the first line of defense against house flies. Cracks around windows and doors where flies are entering should be sealed. Well-fitted screens will also limit their access to buildings. For commercial facilities, air doors can provide effective barriers to fly entry, and light traps attract any of those that still manage to get in. A fly swatter can be used effectively against the stray individual that finds its way into a house. Outdoors, regularly remove (at least twice a week) and dispose of organic waste, including dog feces, to reduce the attractiveness of a site to flies and limit their breeding areas. Garbage should not be allowed to accumulate and should be kept in containers with tight-fitting lids. In general, poor exclusion and lack of sanitation are the major contributors to fly problems.

Fly papers or ribbons are effective at eliminating a few flies, but are not effective enough to manage heavy infestations. Inverted cone traps can be effective if the food attractant used draws flies, but they cannot compete with garbage or other aromatic substances in the surrounding area. Bug zappers should only be used indoors and not be visible from the outside through windows or open doorways. Bug zappers outdoors or improper placement indoors can attract more flies than they kill. They should also not be used near food preparation areas because they may actually result in increased food contamination with insect parts.

Selective use of insecticides against house flies is one component of a total fly management program but should only be used after all possible nonchemical strategies have been employed. To kill flies indoors, a nonresidual pyrethrin space spray or aerosol can be used. Keep the room closed for several minutes after treatment until all the flies are dead. Outside, apply residual insecticides to surfaces such as walls and ceilings that are being used by the flies as resting areas. Fly baits used in trash areas are effective in reducing the number of flies around buildings if good sanitation practices are followed. When flies have access to garbage, however, they will not be controlled by baits. Always follow the directions on the insecticide label for safe application.

LITTLE HOUSE FLY

Identification and Life Cycle

While little house flies (*Fannia* spp.) are found throughout the United States, populations of two species thrive in the particular climatic conditions of southern California. Both *Fannia canicularis* and *Fannia femoralis* can be abundant during the cooler months in southern California and are considered major winter pest flies.

Adults are approximately one-half to two-thirds the size of the house fly, *Musca domestica*, and they lack its distinctive thoracic markings (Fig. 4). *Fannia* at rest hold their wings more over the back than *Musca*, creating a narrower V-shape to the wing outline. Flying clusters of male *Fannia* typically form in areas with still air; these milling groups maintain a position 5 or 6 feet above the ground.

Females typically spend most of their time feeding and laying eggs near the larval development site. The immature stages are adapted to tolerate a wide moisture range in the larval development substrate. Egg laying and larval development frequently occur in animal wastes, but various moist organic materials can serve as suitable substrates. Larvae of *Fannia* spp. are brown in color and spiny (Fig. 5). Backyard compost heaps and decomposing piles of grass clippings can produce large numbers of *Fannia*.

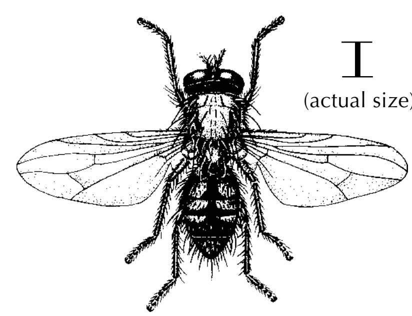

Figure 4. Little house fly.

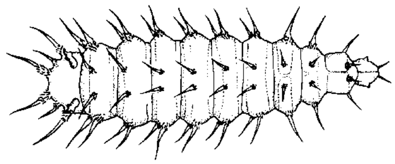

Figure 5. Little house fly larva.

Damage
Little house flies are more reluctant to enter homes than are house flies; instead, they tend to congregate in outdoor areas such as patios, entryways, and garages. Their habit of hovering at face height makes them annoying, though they move readily out of the way when approached. They seldom land and are not considered a significant disease vector.

Strong air currents tend to disperse the male aggregations. As temperatures decline, they seek cover in buildings or protective vegetation. As temperatures rise in late spring and early summer, populations of *Fannia* diminish. In southern California *Fannia* are the main pest fly from November to June, with *Musca domestica* assuming major pest status between June and November.

Management of Little House Flies
Eliminating the breeding site is the preferred method of controlling *Fannia*. Piles of moist, decaying grass clippings are ideal developmental sites, as are accumulations of moist manure. *Fannia* are not attracted to the same fly baits or traps that collect house flies.

FACE FLY

Identification and Life Cycle
Face flies (*Musca antumnalis)* are particularly a problem in rural areas of northern and central California where livestock are present. The hotter, drier weather in southern California is not conducive to their development. The face fly looks virtually identical to the house fly but is somewhat larger and darker in color. Like the house fly it also has sponging mouthparts and cannot bite. However, face fly behavior is distinctive because they are attracted to the eyes, nose, and mouth of cattle and horses.

Female face flies lay their tiny stalked eggs in fresh manure. The yellowish larvae feed on the manure until mature, when they crawl away to a suitable site and pupate in the soil. The life cycle is completed in about 2 weeks.

Damage
Face flies feed on the secretions and sweat of cattle and horses in the summer months. Their habit of feeding around the eyes makes them successful vectors of the causative agent of pinkeye in livestock. They can become pests of humans in fall when swarms of flies enter the walls of buildings to hibernate. Then, on warm days, these hibernating flies can become active and move in large numbers to the inside of the building. Once inside the building they are attracted to light, so they are frequently found flying around windows or lights.

Management of Face Flies
The first step in control is to locate the area where the face flies are hibernating and then treat them directly. The inspection should start on the outside of the south and west sides of the building, because these walls receive the majority of the sun's rays in fall and winter and are therefore usually the warmest parts of the building. The flies are attracted to these warm areas in search of protective harborage for the winter. These flies swarm, then enter cracks and crevices that often lead to structural voids. Sometimes these void spaces are accessible for inspection such as in a crawl space, attic, or false ceiling.

The best nonchemical control method is to vacuum the flies off the surfaces on which they are resting. In areas inaccessible to vacuuming, a residual insecticide such as a pyrethroid can be applied. For application of residual insecticides, contact a reputable pest control company. Dusts are ideal formulations for use in void spaces, but avoid bendiocarb or boric acid dusts because they have given poor results. To prevent future infestations, cracks on the outside that may serve as entry points for flies should be sealed.

STABLE FLY

Identification and Life Cycle
The stable fly (*Stomoxys calcitrans)*, sometimes called the "biting fly" or "dog fly," is a common fly attacking people living in neighborhoods with populations of animals or that are close to livestock facilities. These flies are almost indistinguishable from house flies, except that stable flies have a bayonetlike mouthpart (proboscis) protruding from the front of the head (Fig. 6).

Depending on weather conditions, stable flies typically appear in midspring, become severe in early summer, and decrease in numbers by late summer. During prime breeding times in summer, the stable fly can develop from egg to adult in just 2 weeks. The female fly lays over 100 eggs per batch and may lay four or five such batches in her lifetime, so there is potential for rapid population increases. Piles of moist, decaying plant refuse (grass clippings, hay, silage, etc.) should be considered potential sources of stable flies; this is where female stable flies

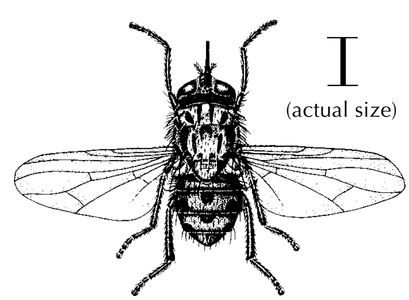

Figure 6. Stable fly.

lay their eggs and where the larvae develop. Larvae of the stable fly resemble larvae of the house fly (Fig. 3). Stable flies do not breed in pure, fresh manure but will develop quite well in manure mixed with hay or other plant material, especially when dampened by urine. Backyard compost heaps and piles of grass clippings are ideal breeding sites for stable fly larvae and may serve as the production source for an entire neighborhood infestation.

Damage

Stable flies bite people and feed on their blood but are not known to be significant vectors of disease. Stable flies also bite animals and tend to feed preferentially on the legs and underside of animals such as cattle and horses. On dogs, stable flies typically feed around the periphery of the ear. Undisturbed, the stable fly can fully engorge in less than 5 minutes. It then flies away to a suitable resting site where it is protected while the blood meal is digested. It is seldom necessary for this pest to fly far to find hosts from which to take a blood meal. When stable flies are a problem in an area, they probably are originating locally.

Management of Stable Flies

The most effective and economical method for reducing populations of the stable fly is elimination of breeding sources. To prevent larval development, moist grass clippings should be spread thinly to dry. Maintain compost piles to promote rapid decomposition of organic matter, which generates heat and makes the pile unsuitable to fly larvae. Another nonchemical measure is pest-proofing the outside of a structure to prevent flies from entering. This technique includes caulking cracks, weather-stripping doors, and installing screens. For protection of dogs and horses that are bothered by stable flies, insect repellents containing permethrin or pyrethrins are effective, but neither provides long-term control, so repeated applications every other day are necessary. Because the stable fly season is relatively short, this approach may be feasible.

REFERENCES

Ebeling, Walter. 1975. *Urban Entomology*. Oakland: Univ. Calif. Agric. and Nat. Resources.

Hedges, Stoy. 1994. *Field Guide for the Management of Structure-Infesting Flies*. Cleveland: Franzak & Foster Co.

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Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits and/or vegetables ready to be picked.

Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse the containers. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Do not pour down sink or toilet. Consult your county agricultural commissioner for correct ways of disposing of excess pesticides. Never burn pesticide containers.

HEAD LICE

Integrated Pest Management in and around the Home

Many families with young children have at least one encounter with the head louse, *Pediculus humanus capitis*. Head lice can infest people of all ages, but children are prone to infestations because of their habit of playing in close contact, sharing hats, headphones, combs and brushes, sleeping bags, stuffed animals, and clothing. In fact, the problem of head lice can be so rampant among preschool and school-aged children that often schools must work in conjunction with many families to control an infestation. An individual family may be able to control head lice at home, but the child can be reinfested when he/she comes in contact with an untreated, infested child.

WHAT TO LOOK FOR

The most common symptom of infestation is intense itching on the back of the head or neck. The itching occurs when the lice bite and suck blood from the scalp. Immediately examine children who repeatedly scratch their heads. Because lice can be hard to spot, examine individual hair shafts, especially at the nape of the neck and behind the ears. With a good light source, look for tiny, white eggs (nits) glued to the hair near the scalp (Fig. 1) and for small, quickly crawling, flat insects. Hatched and unhatched eggs can be differentiated with the aid of a magnifying lens: developing eggs are somewhat dark in color but after hatching the egg cases are white. Nits hatch about 7 to 11 days after being laid, so eggs further than ¼ inch away from the scalp have probably already hatched. An empty egg case can be distinguished from a flake of dandruff because it sticks to the hair, while other particles can be flicked or washed off.

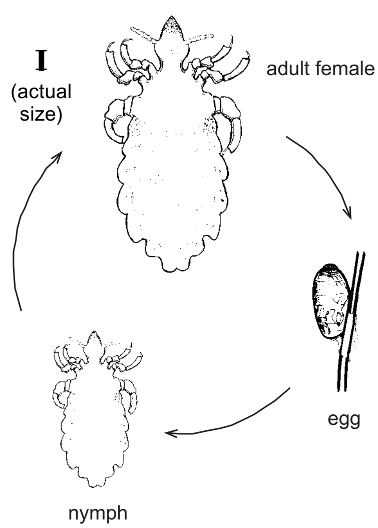

Figure 2. Life cycle of head louse.

LIFE CYCLE

Head lice spend their entire life on the hairy part of the head. The six-legged, wingless adult head louse is about the size of a sesame seed and ranges in color from tan to gray. Each of its six legs ends in a claw that is used to grasp the hair shaft. While head lice can crawl relatively quickly, they cannot hop, fly, or jump. Therefore, direct contact with an infested object or person is required to become infested. Because head lice live and breed completely in human hair, they only survive for about 1 to 2 days if they drop off a person. *They cannot live on family pets.*

The eggs of the louse are laid on the head hairs, usually at the junction of

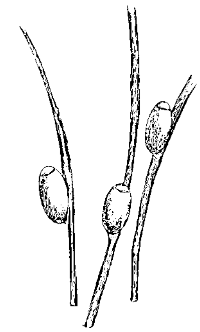

Figure 1. Louse eggs (nits) attached to hair shafts.

the scalp and hair shaft. The egg is coated with a gluelike substance that cements it to the hair. Most eggs are laid at night. Each female produces about three to five eggs in a 24-hour period and lives for about 7 to 10 days. Most of the eggs hatch within 7 to 11 days. To survive, a newly hatched louse must have a blood meal within minutes of birth. Developing lice, or nymphs, take about 7 to 10 days to mature; after an additional day, adult females start laying eggs (Fig. 2). Consequently, the total life span of a head louse from egg through adult averages about 25 days. Because people have a constant body temperature, female lice reproduce continuously throughout the year.

Head lice found in the United States prefer hair that is round in cross section. Hair that is ovoid in cross section, such as the extremely curly hair of African Americans, is not as attractive to lice that are adapted to round hair shafts. While head lice infestations are common in Africa, as in all continents,

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African head lice have claws especially adapted for grasping oval hair shafts. The African variety of head lice is not common in North America and consequently African Americans are much less susceptible to infestations, but they can get head lice.

MANAGEMENT

Head lice are not known to transmit any infectious diseases from person to person. They are more of a nuisance than a health risk problem. It is very important that the methods used to control a head louse infestation not cause more of a problem than the head lice themselves. One major problem for a child with head lice is that they will not be allowed to attend school as long as nits can be found in their hair.

Nits are most effectively removed by combing the hair with a specially designed nit comb. Consider shampoo treatments only when active lice or viable eggs are observed. Although lice and their eggs may be seen without magnification, the viability of eggs cannot be judged without proper magnification and some knowledge of what hatched and unhatched eggs look like. For color photos of nits in various stages of development, see the Web site listed under "Online Resources."

There are four critical steps to controlling an infestation of head lice:

- the use of an effective head louse treatment;
- nit removal from the head (combing);
- removal of lice and nits from the household environment by vacuuming, washing, or freezing objects suspected of being infested; and
- daily head checks and nit removal until infestation is gone, followed by weekly head checks to detect reinfestation.

Head Lice Insecticidal Shampoos

Head lice shampoos contain insecticides and if they are not used properly can cause problems in and of themselves. In addition, resistance to the insecticides in the shampoos among populations of head lice is becoming an increasing problem. Most of the over-the-counter products contain either pyrethrin or permethrin (NIX and Rid). In the past a popular product for the control of head lice was a product called Kwell, which contains the insecticide lindane. Lindane has been associated with a variety of adverse reactions suffered both by people being treated and by people applying the treatment. It is also a troublesome pollutant of wastewater and requires special treatment to be removed. While lindane is still available by prescription, pyrethrin and permethrin are safer, more effective, and less polluting than lindane.

When using a head louse shampoo, minimize body exposure by confining the insecticide to the head hair. Do not use it in the bath or shower, but wash the infested person's hair in a basin or sink so insecticide residues do not reach other parts of the body. The person doing the treatment should wear rubber gloves. Never apply an insecticide to anyone who has open cuts, scratches, or inflammations, and never use these materials on infants without consulting a doctor. In all cases, follow label directions completely and carefully.

While pyrethrin and permethrin are fairly effective, they do not kill all the eggs. In addition, they may not kill all the nymphs and adults, especially if the population is developing resistance to the insecticide. Lice should die within 10 to 30 minutes after treatment with pyrethrin or permethrin. If you find live lice after 30 minutes, suspect that resistance is occurring and discontinue use of that product. If you need a follow-up treatment at the recommended interval on the product label, use a pyrethrin if you used permethrin the first time, or vice versa, but do not resort to dangerous practices such as applying other insecticides, pet flea and tick shampoo, or materials such as kerosene!

You will still need to supplement shampoo treatment with combing the hair (as described below) and some cleaning of the house and personal effects likely to be infested. If you do not remove nits with hair combing, the infestation will reoccur and the additional use of the treatment products will increase the treated person's exposure to these insecticides, as well as help select for resistance in the head louse population.

If you want to avoid insecticides entirely, you could try using soap shampoos that contain coconut or olive oils. Most soaps kill all stages of the louse except the egg. Four shampoos, each about 3 days apart, should kill most of the lice as each successive shampoo kills newly hatched nymphs. Always combine shampooing with daily combing and a cleaning of the environment.

Enzymatic treatments, including shampoos that claim to dissolve eggs, the cement that attaches eggs to the hair, or the exoskeleton of the adults, are also available to use against head lice. Although these materials are very appealing because of their relative nontoxicity, in university-conducted research trials none of them has yet proven to work as advertised.

While shampoos with coconut oil may help in controlling infestations of head lice, they are not effective as a repellent against lice to prevent infestation or reinfestation.

Hair Combing

Combing the hair to remove nits and lice that survived the shampoo treatment is the key to successfully controlling this pest. This process is time consuming but critical for success. If you do not completely remove all nits, reinfestation will most likely occur. This process should be repeated daily as long as nits and lice are still found on the head. Many people use nit combs to remove nits from the hair shaft. The most effective nit comb is a metal one specially designed for removing head lice and their eggs; plastic combs, even the ones that come with the lice shampoos, are not as effective. Metal lice combs can be found at drug stores or ordered from the National Pediculosis Association, Inc., listed in "References," which has a specially designed nit comb called the

LiceMeister™. The infested hair can also be cut out with small safety scissors.

The person to be treated should be seated near a good light source. The materials you will need for hair combing are

- a box of tissues and plastic bag;
- a good nit comb or a pair of safety scissors;
- a lamp that allows you to direct it to the area you are working on;
- hair clips to pin up the sections of hair that have been combed; and
- something to entertain the person being treated—especially if it is a child.

Figure 3. Combing for head lice.

Following the use of a head louse shampoo, use regular shampoo and conditioner to wash the hair (the hotter the water the better because lice are very vulnerable to high temperatures, but be careful not to hurt young children whose scalps are more sensitive to hot water than scalps of older people). Leave the conditioner in and towel dry the hair. Then comb the hair using a regular comb to remove snarls and the accumulation of any suds.

Starting at the crown of the head, separate out a section of hair that is about 1 inch by ½ inch; hold it out from the head (Fig. 3). Insert the louse comb at the base of the hair section as close as possible to the scalp, and pull the comb slowly through the hair. Be sure to slant the comb so that the curved side of the teeth is towards the head. If you aren't using a comb, go through each small section of hair and use your fingernails to pull the eggs off the hair, or cut the individual hairs off. Use the tissues to clean any lice or debris from the comb following each combing or to collect nits and hair that are removed, and put the tissue in the plastic bag. Continue to comb the section of hair until you feel sure it is free of nits or lice, then pin it out of the way with a hair clip and start on the next section of hair. If the hair dries during the combing process, wet it again with water to reduce pulling and hair loss. When all the hair has been combed, rinse it thoroughly with water and then dry. After the hair is completely dry, check the entire head for stray nits and remove them individually.

To clean up, soak the comb in hot soapy ammonia water for 15 minutes or boil it for 15 minutes (only the metal ones). An old toothbrush is useful in removing the debris that is lodged in the teeth of the comb, as is dental floss. The plastic bag should be sealed and disposed of.

It is not necessary to cut a person's hair if they become infested with lice. However, the shorter the hair, the easier it is to comb for lice. If successive treatments for lice have been made and the infestation persists, or if you want to control the infestation quickly, this is an option to consider.

Cleaning Your Home

It is important to wash the clothing and bedding of the infested person at the time he or she is initially treated. Head lice will be killed if infested articles are washed in hot water (at least 140°F) and dried in a hot dryer. If an article can't be washed, have it dry cleaned. Another alternative that works well for headgear such as earphones and bike helmets is to place them in a plastic bag and put them in a freezer. If the freezer is 5°F or lower, all lice and eggs should be dead within 10 hours. Also clean other personal items such as stuffed animals, car seats—any object that might have come in contact with the infested person's head. Vacuuming carpets and upholstery will effectively remove hair containing nits in these areas. While it is important to clean objects that come in contact with the head, in general lice stay on the head. Therefore it is not necessary to go into a frenzy of house cleaning and it is especially not necessary to use any insecticide to spray rooms or objects. Time and effort are much better spent combing nits and lice from the hair.

Contacting Friends and the School

It is important to contact anyone your child has had close contact with in the recent past to let them know of a head louse infestation. The reason for this is simple: the infestation came from somewhere, and if the source or other recently infested people are not treated, your child can become reinfested when contact is renewed. That means you will need to go through all of the above treatment procedures again.

Nits are laid at the junction of the scalp and hair shaft, and they hatch in 7 to 11 days. The average growth rate of human hair in children is 0.4 mm per day, so by the time the nit has hatched it has moved about 2 to 3 mm away from the scalp. Therefore, nits further than ¼ inch from the scalp have probably hatched and are no longer viable. For this reason, the "no nit" policy in place at many schools does not have a biological basis, but most schools do not have personnel with expertise in distinguishing the viability of nits.

If head louse infestations are occurring at your child's school, check your child's head nightly using a metal lice comb and a good light source. The earlier an infestation is discovered, the easier it will be to treat. Avoid unnecessary treatments with head louse insecticides; use them only when lice or louse eggs have been found on a child's head to minimize the child's exposure to these materials. Also, the use of pesticide products can be harsh on a child's hair and very drying to the scalp, which in turn can cause an increase in dried scalp flakes and dandruff that might be mistaken for nits. Remember, nits are glued to the hair shaft and are not easily removed; they are oval-shaped and glued at an angle to the side of the hair. If in doubt, use a good magnifying lens to verify a suspected nit or louse (and compare what you find to the photos on the Web site listed under "Online Resources") because pesticide treatment is not appropriate for hair debris.

REFERENCES AND RESOURCES

Ebeling, W. 1975. *Urban Entomology*. Oakland: Univ. Calif. Agric. Sci. pp. 455-459.

Hitchcock, J. C., R. M. Davis, and V. Kramer. March 1996. Head lice (*Pediculus humanus capitis*): A heady, nitpicky, and lousy problem. *Calif. Morbidity*. Berkeley: Div. Communicable Disease Control.

National Pediculosis Association, Inc., P.O. Box 610189, Newton, MA 02161. Phone: 617-449-NITS. Online: http://www.headlice.org
To order a nit comb call 1-888-542-3634.

Wilson, B. 1995. Ectoparasites. In Mandell G. L., J. E. Bennett, and R. Dolin, eds. *Principles and Practice of Infectious Diseases.* New York: Churchill Livingstone, pp. 2558–2560.

Online Resources

Pollack, R. J. Head lice information. www.hsph.harvard.edu/headlice/photos.html

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

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WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

Head Lice Information Packet for Schools

This Sample Information Packet contains the following:

1. Guidelines on Head Lice Control for School Districts and Child Care Facilities from the California Department of Health Services

2. Guidelines for Parents on Control of Head Lice from the California Department of Health Services)

3. Sample Letter from School to Parents

Guidelines on Head Lice Control for School Districts and Child Care Facilities

(Revised October 2001)

Disease Investigations and Surveillance Branch

California Department of Health Services (DHS)

These guidelines are provided to assist local health departments, elementary schools, preschools, and child-care facilities in determining policies and procedures.

No Nit Policy

DHS recommends that schools and childcare facilities maintain a no nit policy to prevent readmission of lice-infested children. This practice will assure parents the school is working to prevent head lice transmission. The essential components of a no nit policy are the following:

- Early detection through routine screening
- Denial of admission to children with lice or nits (Nits that are more than º inch from the scalp have already hatched. If there are no lice and no nits close to the child's scalp, you might consider that the child is no longer infested.)
- Distribution of educational material to school staff and parents on head lice, nit combing, and treatment such as the DHS "Guidelines for Parents to Control Head Lice" (Revised October 2001)

Screening of all students should be conducted the first week that students return to school from vacations. DHS continues to support no nit policies until research with a larger sample size and less variables can validate the results of a study by the Centers for Disease Control and Prevention (CDC) published in Pediatrics in the May 2001 (Vol. 157 No. 5) issue. In that study, CDC stated that children with fewer than 5 nits that are a º inch or less from the scalp probably won't develop lice.

Detection of Head Lice

When a child is found with head lice contact the parents. Provide them with educational material on nit combing and treatment, and stress the importance of daily combing to remove all nits. If possible, schools should distribute metal nit combs to the parents. All children in the family should be checked for head lice. It is more likely that a child becomes infested in the home environment by sharing beds or by head-to-head contact with siblings and playmates, than at school. Schools may have a policy that notification be sent home with all children in the classroom when a classmate has lice, but this is not necessary when only nits are found.

Chronic Cases

If a child is found consistently infested with head lice, the child should be deemed a "chronic" head lice case. A chronic case is a child found infested during three separate months during a school year or for six consecutive weeks. It is important for schools to identify these children as their continuing infestations may signify other family or economic problems. These chronic cases should be reported to the school attendance review board and be addressed by a multi-disciplinary work group. The work group could consist of representatives from the local health department, social services, the school (district) nurse, and other appropriate individuals in determining the best approach to identifying and resolving the family problems that are impacting the school attendance of the child.

Environmental Control

Pesticide application to the school environment or at home is not recommended. Lice usually die within 2 days without a blood meal. Always keep each child's hat and other clothing on separate hooks. Once a child is found infested with head lice, the classroom can be vacuumed once a day to decrease the remote possibility of transmission of head lice. Pillows and other classroom items may have nits or lice on them but are unlikely sources of infestation. They can be put in a dryer and run on hot for 20 minutes or placed in sealed plastic bags for two weeks (nits take 8-10 days to hatch) to prevent hatching lice from getting a blood meal on a child's head.

Treatment

Parents need to understand that the most important components of head lice control are thorough combing out of nits and lice with a metal nit or flea comb every day and a single treatment. Several brands of metal (not plastic) nit combs are available at local pharmacies including the LiceMeisterÆ* metal comb with long teeth. Metal flea combs also work well for nit combing and can be bought at pet stores.

The current product of choice for treatment is a cream rinse formulation containing permethrin, such as NixÆ*. Products containing pyrethrins are also acceptable. Preliminary results from two separate studies on head lice resistance in California in 2000 indicate no resistance in one and some resistance to permethrin in the other. Treatment failure may be due to misidentifying the substance on the hair shaft as nits or not realizing it may take 8-12 hours for lice to die. Parents whose children continue to have lice after one treatment with permethrin and/or pyrethrin treatment along with thorough combing every day should be encouraged to contact their physician about an OvideÆ* prescription, which was made available to Medi-Cal eligible families in 2000.

California legislation prohibited the use of prescription products containing lindane (KwellÆ*) after January 2002. More information on treatment is available at the CDC website: http://www.cdc.gov/ncidod/dpd/parasitesheadlicefactsht_head_lice_treating.htm

There is no scientific evidence to support the use of products such as vinegar or enzyme-based compounds advertised to dissolve the glue on the nits (to ease their removal) or kill the nits. Similarly, there are no scientific data to support claims that mayonnaise, olive oil, or tea tree oil on the hair "suffocates" the nits and lice.

Please contact your local health department for more information. These head lice guidelines, one for parents, and other DHS publications can be found at the following website: http://www.dhs.ca.gov/ps/dcdc/html/publicat.htm

*Use of a product name is for identification purposes only and does not constitute endorsement.

Guidelines for Parents on Control of Head Lice

Disease Investigation and Surveillance Branch

California Department of Health Services

Head lice continue to be a problem in homes, day care centers, elementary and preschools in California and elsewhere. Head-to-head contact or, less frequently, an exchange of hats, clothing, combs, brushes, barrettes, helmets, scarves, headphones, and other personal items can transmit lice from an infested child to others. Most schools have a "no-nit" policy, so treatment and use of a nit comb are needed before an infested child can return to school.

Inspecting A Child's Head And Nit Combing

Daily removal of lice and their eggs ("nits") from a child's hair with a metal nit or flea comb is the most important lice control measure. It is important to inspect the child's and sibling's hair thoroughly, especially close to the scalp at the neckline and behind the ears. Complete nit combing of the entire head has to be performed every day until no more lice or nits are found. Several brands of combs are available. The LiceMeisterÆ* metal comb with long teeth is available from the National Pediculosis Association (800-446-4672), is easy to use, and costs about $10. This and other effective devices may also be purchased at your local pharmacy. Any nits (correct identification of actual nits is critical) that cannot be combed out must be removed either by picking them out with the fingernails or by snipping the hair between the scalp and where the eggs are attached.

Treatment For Head Lice

Permethrin or pyrethrin is the active ingredient in most over-the-counter control products. The active ingredient of choice is **permethrin**, which is currently in NixÆ* cream rinse formulation. Follow the label directions carefully, but do not go beyond the recommended one-time for application without consulting a physician. Do not treat a second time until 7-10 days following the first treatment. Treatment "failures" usually result from the following: 1) incorrect identification (not lice), 2) incomplete combing out or removal of the nits (eggs), 3) not realizing it may take 8-12 hours for the lice to die, 4) lice re-infestation, or 5) not strictly following labeled directions. Resistance could be considered as a possible reason for failure if none of the above applies. If neither permethrin nor pyrethrin products are effective, one alternative is 0.5% malathion (OvideÆ*), which requires a prescription. The label of this alcohol-based product states 8-12 hours contact time is needed, then remove nits with a fine-toothed comb.

Non-Recommended Control Measures

There is no convincing scientific evidence to support use of products such as vinegar or advertised compounds to dissolve the glue on the nits (to ease their removal) or kill the nits. In addition, there is no documented scientific data to support claims that mayonnaise or olive oil on the hair "suffocate" the nits and lice.

Lice Biology And Washing Recommendations

Lice die within 1-2 days without a blood meal. Nits take 8-10 days to hatch and then it takes about nine or more days for the lice to become adults and lay eggs. Since it is possible for nits or lice to be on items used by the child prior to treatment, clothing and bedding should be washed in hot water. Dry on hot cycle for at least 20 minutes. Items that are not washable should be dry cleaned or put in a sealed plastic bag for two weeks to prevent hatched lice from getting a blood meal. Soak combs, brushes, hair bands, and barrettes in soapy hot water for one hour (or boil for five minutes). Carpets and furniture can be vacuumed daily. THERE IS NO NEED TO APPLY PESTICIDES IN THE HOME!

Please contact your local health department if there are additional questions. These guidelines are on the Department of Health Services web site at http://www.dhs.cahwnet.gov/ps/dcdc/html/publicat.htm

*Use of a product name is for identification purposes only and does not constitute endorsement.

Sample Letter from School to Parents

Dear Parents of ______________________ ,

In a screening at your child's school, your child was found to have head lice. A diagnosis of head lice means that crawling lice or head lice eggs (also known as nits) attached to the hair were found.

Head lice are small, wingless insects about the size of a sesame seed. They only live on the human scalp (not on family pets) and feed by sucking blood. Head lice range in color and can be white, gray, brown or red. The female louse lays eggs in the head hairs, usually at the junction of the scalp and hair shaft. The eggs hatch within 7 to 10 days and the newly hatched louse must have a blood meal within minutes in order to survive. If a louse drops off a person, it only survives for 1 to 2 days.

Four Critical Steps in Treatment:

1. Nit removal from the head by combing is the most important lice control measure. Complete nit removal is time consuming but it is **critical** for successful treatment;
2. Use of an effective head louse treatment;
3. Removal of all lice and nits from the environment by washing or vacuuming. There is no need to spray pesticides at home;
4. Daily head checks and nit removal until infestation is gone followed by weekly head checks to detect reinfestation.

Students with lice/nits are not allowed to attend school. This guideline is from the Center for Disease Control.

When your child returns to school after being sent home with head lice, a thorough head check will be done to ensure that all nits and lice are gone.

Please see the attached materials from the California Department of Health Services regarding head lice and their treatment.

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School Nurse

SECTION 7.1

IPM For Scorpions in Schools

Adapted from Daar et al., 1997

Scorpions live in a wide variety of habitats from tropical to temperate climates and from deserts to rain forests. In the U.S., they are most common in the southern states from the Atlantic to the Pacific. All scorpions are beneficial because they are predators of insects.

The sting of most scorpions is less painful than a bee sting. There is only one scorpion of medical importance in the United States: the sculptured or bark scorpion, Centruroides exilicauda (=sculpturatus). Its sting is most dangerous to young children and infants. This species occurs in mostly in Arizona but sometimes along the west bank of the Colorado River in California.

Biology

Scorpions range worldwide from _ to 8 1/2 inches in length, but all scorpions are similar in general appearance. Scorpions do not lay eggs. They are viviparous, which means they give birth to live young. As embryos, the young receive nourishment through a kind of placental connection to the mother's body. When the young are born, they climb onto the mother's back where they remain from two days to two weeks until they molt (shed their skin) for the first time. After the first molt, the young disperse to lead independent lives. Some scorpions mature in as little as six months while others take almost seven years.

All scorpions are predators, feeding on a variety of insects and spiders. Large scorpions also feed on small animals including snakes, lizards, and rodents. Some scorpions sit and wait for their meal to come to them while others actively hunt their prey. Scorpions have a very low metabolism and some can exist for 6 to 12 months without food. Most are active at night. They are shy creatures, aggressive only toward their prey. Scorpions will not sting humans unless handled, stepped on, or otherwise disturbed.

It is rare for scorpions to enter a building since there is little food and temperatures are too cool for their comfort. There are some exceptions to this rule. Buildings in new developments (less than three years old) can experience an influx of scorpions because the construction work has destroyed the animals' habitat. In older neighborhoods, the heavy bark on old trees provide good habitat for scorpions, and they may enter through the more numerous cracks and holes in buildings in search of water, mates, and prey. In addition, buildings near washes and arroyos that are normally dry may become refuges for scorpions during summer rains.

Scorpions do not enter buildings in winter because cold weather makes them sluggish or immobile. They are not active until nighttime low temperatures exceed 70°F. Buildings heated to 65° or 70°F provide enough warmth to allow scorpions to move about. Scorpions found inside buildings in cold weather are probably summer visitors that never left. Although scorpions prefer to live outdoors, they can remain in buildings without food for long periods.

Stings

A scorpion sting produces considerable pain around the site of the sting, but little swelling. For four to six hours, sensations of numbness and tingling develop in the region of the sting, and then symptoms start to go away. In the vast majority of cases, the symptoms will subside within a few days without any treatment.

If the sting is from a bark scorpion, symptoms can sometimes travel along nerves, and tingling from a sting on a finger may be felt up to the elbow, or even the shoulder. Severe symptoms can include roving eyes, blurry vision, excessive salivation, tingling around the mouth and nose, and the feeling of having a lump in the throat. Respiratory distress may occur. Tapping the site of the sting can produce extreme pain. Symptoms in children also include extreme restlessness, excessive muscle activity, rubbing at the face, and sometimes vomiting. Most vulnerable to the sting of the bark scorpion are children under five years and elderly persons who have an underlying heart condition or respiratory illness. The greatest danger to a child is the possibility of choking on saliva and vomit as side effects of the sting. Stings occurring in children, or in patients experiencing severe symptoms, should be seen by a medical practitioner as soon as possible.

Antivenin for the bark scorpion is produced at Arizona State University in Tempe and is available in Arizona but not in other states. The therapeutic use of antivenin is still experimental. People have been treated without antivenin for many years, and in areas where antivenin is unavailable, people are monitored closely by medical professionals until the symptoms subside.

Sidebar 7.1-1

Avoiding Scorpion Stings

Schools in areas where encounters with scorpions are likely should teach children and adults how to recognize scorpions and to understand their habits. Focus on scorpion biology, behavior, likely places to find them, and how to avoid disturbing them.

At home, children and parents should be taught to take the following precautions to reduce the likelihood of being stung:

- Wear shoes when walking outside at night. If scorpions are suspected indoors, wear shoes inside at night as well.
- Wear leather gloves when moving rocks, boards, and other debris.
- Shake out shoes or slippers before they are worn, and check beds before they are used.
- Shake out damp towels, washcloths, and dishrags before use.
- When camping, shake out sleeping bags, clothes, and anything else that has been in contact with the ground before use.
- Protect infants and children from scorpions at night by placing the legs of their cribs or beds into clean wide-mouthed glass jars and moving the crib or bed away from the wall. Scorpions cannot climb clean glass.

Detection and Monitoring

To determine where scorpions are entering, inspect both the inside and outside of the building at night (when scorpions are active) using a battery-operated camp light fitted with a UV (black) fluorescent bulb. Scorpions glow brightly in black light and can be spotted several yards away.

Always wear leather gloves when hunting scorpions. Places to check inside the building include under towels, washcloths, and sponges in bathrooms and kitchen; under all tables and desks, since the bark scorpion may climb and take refuge on a table leg or under the lip of a table; and inside storage areas. Outside, check piles of rocks and wood, under loose boards, and in piles of debris. After the following treatment strategies have been implemented, monitoring with the black light should continue to verify population reduction.

Management Options

Physical Controls

In most cases, physical controls will be adequate to manage a scorpion problem.

Removal of Scorpions

Any scorpions found during monitoring can be picked up using gloves or a pair of kitchen tongs, and transferred to a clean, wide-mouthed glass jar. Scorpions cannot climb clean glass. You can also invert a jar over a live scorpion and then slide a thin piece of cardboard under the mouth of the jar to trap the scorpion inside. Once a scorpion is captured, drop it into a jar of alcohol or soapy water (water without soap will not work) to kill it.

Habitat Modification

If you discover areas near school buildings that harbor a number of scorpions, you can try to alter the habitat to discourage them. Woodpiles, rocks, loose boards, and other debris should be removed from the immediate vicinity of the building.

If there are slopes on the school grounds that are faced with rip rap (large rocks placed on a slope or stream bank to help stabilize it), or other similar areas highly attractive to scorpions, place a barrier of aluminum flashing between the riprap and the school to prevent scorpion access. The flashing must be bent in an "L" shape away from the building. The other edge of the flashing should be buried a short distance from the rocks, deep enough in the soil so that the L shape will not fall over and lean on the riprap. Make the height of the barrier before the bend greater than the height of the riprap to prevent scorpions from standing on the rocks and jumping over the barrier.

Carry a caulking gun during nighttime inspections inside and outside the building to seal any cracks and crevices found. If scorpions are entering through weep holes in windows or sliding doors, cover the holes with fine-mesh aluminum screening, available from hardware or lumber stores. The ends of pipes that are designed as gray water drains should be fitted with loose filter bags, or makeshift end-pieces made from window screen. The screened end will prevent scorpion access to the drainpipe, sink, and other parts of the building.

It is important to continue nighttime patrols and caulking until all entryways have been located and sealed, and all the scorpions in the building have been captured and killed. Once the access routes are sealed, and all indoor scorpions have been removed, only doorways provide access, unless the scorpions ride in on logs and other materials. Glazed tiles can be placed around the perimeter of the buildings, and under or around doors and windows as part of the decor and as practical scorpion barriers. Scorpions have difficulty crossing smooth tiles unless the

Sidebar 7.1-1

First Aid for Scorpion Stings

Most scorpion stings are similar to a bee or wasp sting. Like bee or wasp stings, the majority of scorpion stings can be treated at school or the victim's home. The sting from a bark scorpion should be treated by a medical professional, after first aid is given.

First aid for a scorpion sting includes the following:

- Calm the victim.
- Do not use a tourniquet.
- Wash the area with soap and water.
- Apply a cool compress (an ice cube wrapped in a wet washcloth), but do not apply ice directly to the skin or submerge the affected limb in ice water.
- To reduce pain, over-the-counter pain relievers such as aspirin or acetaminophen can help.
- Elevate or immobilize the affected limb if that feels more comfortable.
- Do not administer sedatives such as alcohol.
- Seek medical assistance at once for stings occurring in children or if the victim is experiencing severe symptoms, such as shortness of breath or dizziness.

grout line is wide. Wood storage should be elevated above the ground since scorpions like contact with moist soil. Before bringing materials inside, such as logs, bang them on a stone to dislodge any scorpions.

Traps

A simple trap made of damp gunnysacks laid down near the building in the evenings may be useful for monitoring and trapping. Scorpions may seek out the moist environment under the sacks where they can be collected in the morning. This trap is most effective when used before summer rains.

Chemical Controls

In general, preventing scorpion problems is better than trying to kill these creatures with pesticides. Spraying the perimeters of buildings is both unnecessary and ineffective. Scorpions can tolerate a great deal of pesticide in their environment. Using physical controls along with education to reduce the fear of scorpions will help prevent unnecessary chemical treatments.

Bibliography

Bio-Integral Resource Center (BIRC). 1996. 1997 directory of least toxic pest control products. IPM Practitioner 18(11/12):1-39.

Cloudsley-Thompson, J.L. 1968. Spiders, Scorpions, Centipedes and Mites. Pergamon Press, New York. 278 pp.

Daar, S., Drlik, T., Olkowski, H., and Olkowski, W. 1997. IPM for Schools: a How-To Manual. Bio-Integral Resource Center, Berkeley, CA. 215 pp.

Keegan, H.L. 1980. Scorpions of Medical Importance. Jackson University Press, Jackson, MS. 140 pp.

Mallis, A. 1982. Handbook of Pest Control. Franzak and Foster, Cleveland, OH. 1101 pp.

Olkowski, W., S. Daar, and H. Olkowski. 1991. Common-Sense Pest Control: Least-toxic solutions for your home, garden, pets and community. Taunton Press, Newtown, CT. 715 pp.

Polis, G.A., ed. 1990. The Biology of Scorpions. Stanford University Press, Stanford, CA. 587 pp.

Smith, R.L. 1982. Venomous animals of Arizona. Cooperative Extension Service, College of Agriculture, University of Arizona, Tucson, AZ, Bulletin 8245. 134 pp.

Smith, R.L. 1992. Personal communication. Associate Professor, Entomology Dept., University of Arizona at Tucson.

SILVERFISH AND FIREBRATS

Integrated Pest Management in the Home

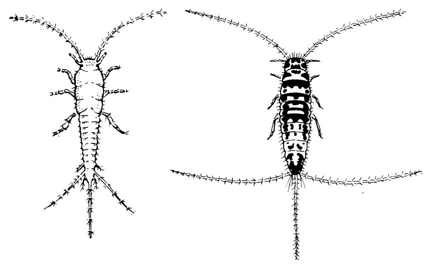

Figure 1. Silverfish *(left)*; **Firebrat** *(right)*.

If the pages and bindings of books in your bookcase have been chewed on, suspect the look-alike household pests—silverfish and firebrats.

DESCRIPTION

Silverfish are shiny, silver or pearl gray, and firebrats are shiny, mottled gray. Adults of both are slender, wingless, soft-bodied insects 1/3 to 1/2 inch long. They have scaly bodies that taper gradually to the rear with two slender antennae in front and three long, thin appendages in back. The presence of scales around or under the damage is a good indication that these pests are the culprits.

HABITS

During the day, both silverfish and firebrats hide. If the object they are hiding under is moved, they dart toward another hiding place. They come out at night to seek food and water. Items on their preferred menu are cereals, moist wheat flour, books, any paper on which there is glue or paste, sizing in paper (including wallpaper) and book bindings, and starch in clothing. They can live for several months without food.

WHERE FOUND

Silverfish live and develop in damp, cool places, particularly in basements and laundry rooms. Firebrats thrive best in very warm, moist places. They may be found around ovens, heating units, fireplaces, hot water pipes, the attic in summer, and near the furnace in winter. In apartments and homes, the insects crawl along pipelines and through openings in the walls or floors from basements to rooms above.

Silverfish and firebrats can be found in any part of the home. Because they are seeking food, they choose bookcases, closets, and places where books, clothing, starch, or sugar foods are available. They hide in baseboards and around window and door frames from which they seek out food sources. Sometimes they are seen in the bathtub or sink. They do not crawl up through the drain, but fall in and cannot climb up the slippery sides to escape.

Large numbers of these insects may invade new homes from surrounding wild areas, especially as these areas dry in summer. They may be brought in on lumber, wallboard, or similar products. Freshly laid cement and green lumber supply humidity, and wallpaper paste provides them with food.

MANAGEMENT

To keep silverfish and firebrats away, keep basements, laundry rooms, and bathrooms, especially shower stalls, clean and dry. Plug or putty holes or spaces around pipes. Repair leaks and drips in plumbing. Clean out closets periodically. Collections of magazines, papers, and books provide food for them. Occasionally, move books around in a bookcase. Keep foods in containers with tight lids.

There are several kinds of commercially available products that control silverfish or firebrats: household sprays containing various pyrethroids (such as bifenthrin, tetramethrin, phenothrin), dusts, boric acid powder, and foggers are labeled for control of these pests. Insecticides are not needed, however, for the control of a few solitary insects, and their use should be reserved for large infestations. If an occasional stray firebrat or silverfish is observed, it can be killed easily with a rolled-up newspaper.

- Granular and dust baits are available and can be very effective if placed closer to the pests' shelter than other food sources.

- To use an aerosol spray, apply it directly to cracks in doors and window casings, baseboards, closets, bookcases, and places where pipes go through walls. Caution: Some sprays have oil solution bases; do not apply these near electric motors, gas pilot flames, or other places where they may start fires. Follow label directions and cautions.

- To use dusts or boric acid powder, apply them with a bulb duster, powder blower, or a plastic squeeze bottle to leave a fine layer of the material in the area to be treated. If the layer is too thick, the

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surface will be slippery. Puff in places mentioned above for sprays, paying special attention to cracks and crevices. Follow label directions and cautions. Inorganic dusts such as boric acid and silica gel remain effective indefinitely in dry locations. If they get wet, they become too packed for easy pickup by the insects, so re-treat the area.

- Foggers are not generally recommended to treat silverfish and firebrats unless the infestation is severe. Be sure to read the label directions carefully and follow all instructions.

A properly and thoroughly applied insecticide will show results in a few weeks. If control is not achieved in 2 or 3 weeks, silverfish are probably coming from untreated areas. Seek these areas out for treatment and also eliminate water sources—large populations of silverfish and firebrats cannot be controlled unless their water sources are eliminated.

In general, bait packets have not been very successful in treating silverfish and firebrats because these pests tend not to feed on them.

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For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits and/or vegetables ready to be picked.

Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse the containers. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Do not pour down sink or toilet. Consult your county agricultural commissioner for correct ways of disposing of excess pesticides. Never burn pesticide containers.

SPIDERS

Integrated Pest Management In and Around the Home

Many people fear or dislike spiders but, for the most part, spiders are beneficial because of their role as predators of insects and other arthropods, and most cannot harm people. Spiders that might injure people—for example, black widows—generally spend most of their time hidden under furniture or boxes, or in woodpiles, corners, or crevices. The spiders commonly seen out in the open during the day are unlikely to bite people.

IDENTIFICATION

Spiders resemble insects and sometimes are confused with them, but they are arachnids, not insects. Spiders have eight legs and two body parts—a head region (cephalothorax) and an abdomen. They lack wings and antennae. Although spiders often are found on plants, they eat mainly insects, other spiders, and related arthropods, not plants. Most spiders have toxic venom, which they use to kill their prey. However, only those spiders whose venom typically causes a serious reaction in humans are called “poisonous” spiders.

Black Widow Spider

The black widow spider, *Latrodectus hesperus* (Fig. 1), is the most common harmful spider in California. Venom from its bite can cause reactions ranging from mild to painful and serious, but death is very unlikely and many symptoms can be alleviated if medical treatment is obtained. Anyone bitten by this spider should remain calm and promptly seek medical advice; it is helpful if the offending spider can be caught and saved for identification.

The typical adult female black widow has a shiny black body, slender black legs, and a red or orange mark in the shape of an hourglass on the underside of the large, round abdomen (Fig. 2). The body, excluding legs, is $^{5}/_{16}$ to $^{5}/_{8}$ inch long. The adult male black widow is one-half to two-thirds the length of the female, has a small abdomen, and is seldom noticed. The male black widow does possess venom, but its fangs are too small to break human skin. The top side of its abdomen is olive greenish gray with a pattern of cream-colored areas and one light-colored band going lengthwise down the middle. The hourglass mark on the underside of the abdomen typically is yellow or yellow-orange and broad-waisted. The legs are banded with alternating light and dark areas. Contrary to popular belief, the female black widow rarely eats the male after mating, but may do so if hungry. Like males, young female black widow spiders are patterned on the top side. In the early stages they greatly resemble males, but gradually acquire the typical female coloration with each shedding of the skin. In intermediate stages they have tan or cream-colored, olive gray, and orange markings on the top side of the abdomen, a yellowish orange hourglass mark on the underside, and banded legs. Only the larger immature female and adult female spiders are able to bite through a person’s skin and inject enough venom to cause a painful reaction.

Webs and Egg Sacs. The web of the black widow is an irregular, tough-stranded, sticky cobweb mesh in which the spider hangs with its underside up. During the day it often hides under an object at the edge of the web or stays in a silken retreat in the center. The black widow may rush out of its hiding place when the web is disturbed, especially if egg sacs are present. The egg sacs are mostly spherical, about $^{1}/_{2}$ inch long and $^{5}/_{8}$ inch in diameter, creamy yellow to light tan in color, opaque, and tough and paperlike on the surface. A female may produce several egg sacs. Tiny, young black widows, which are nearly white in color, disperse to new locations by ballooning and infest new areas.

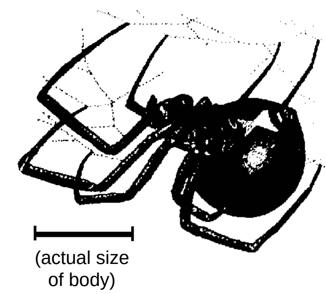

Figure 1. Adult black widow spider.

Where the Spiders Live. Black widow spiders occur in most parts of California. They and their associated webs usually are found in dark, dry, sheltered, relatively undisturbed places such as among piles of wood, rubbish, or stones; in culverts, hollow stumps, and old animal burrows; in garages, sheds, barns, crawl spaces, utility meter boxes, and outhouses; and sometimes among plants. People are most likely to be bitten when they disturb the spider while they are cleaning out or picking up items in such places. A sensible precaution is to always wear gloves and a longsleeved shirt when working in areas that have been undisturbed for a time and where there are good hiding places for spiders.

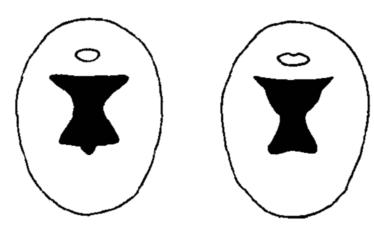

Figure 2. Two variations of hourglass markings of black widow spider.

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Effects of the Bite. The symptoms of a black widow bite are largely internal; little more than local redness and swelling may develop at the bite site. The internal effects may range from mild to severe. Pain tends to spread from the bite to other parts of the body and muscular spasms may develop. In severe cases the abdominal muscles may become quite rigid. Other effects can include profuse sweating, fever, increased blood pressure, difficulty breathing and speaking, restlessness, and nausea. Typically, the pain and other symptoms reach a maximum within a day of the bite, then gradually subside over the next 2 to 3 days. Most people who are bitten spend a few hours under observation by a physician but do not develop symptoms severe enough to require treatment. Small children, the elderly, and persons with health problems are likely to suffer some of the more severe consequences of the bite. Black widow bites are fairly common in California.

Yellow Sac Spider

The common house-dwelling agrarian sac or yellow sac spider, *Cheiracanthium inclusum*, is a small spider that spins a silken sac web in the corners of ceilings and walls, and behind shelves and pictures; it is also commonly found outdoors in shrubbery. This spider is light yellow and has a slightly darker stripe on the upper middle of the abdomen (Fig 3). The eight eyes of this spider are all about equal in size and arranged in two horizontal rows (Fig. 4).

Yellow sac spiders can be seen running on walls and ceilings at night and quickly drop to the floor to escape if they are disturbed. Bites usually occur when the spider becomes trapped against a person's skin in clothing or bedding. It is estimated that sac spiders are responsible for more bites on people than any other spider. Typical symptoms of a bite include initial pain, redness, and sometimes swelling. A small blister may form, often breaking, leaving a sore that heals over a period of several weeks. Soreness near the bite may last for a few days to several weeks or may not occur at all, depending on the individual.

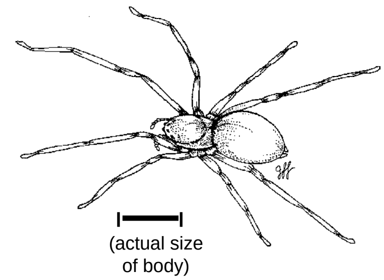

Figure 3. Adult yellow sac spider.

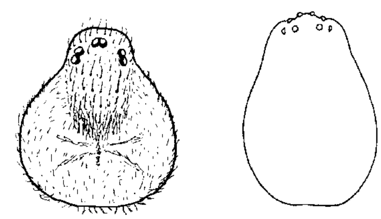

Figure 4. Head region of recluse spider *(left)* and yellow sac spider *(right)*. Note the arrangements of the eyes: the recluse spider has six eyes arranged in three pairs and the yellow sac spider has eight eyes arranged in two rows of four.

Recluse Spiders

Recluse spiders of the genus *Loxosceles* include the well-known brown recluse spider, *L. reclusa*, which does not occur in California. While the brown recluse has occasionally been brought into California in household furnishings, firewood, and motor vehicles, it does not reside in the state. However, another recluse spider, the Chilean recluse spider *(L. laeta)*, was introduced into Los Angeles County in the late 1960s. In Chile, South America it is known to have a bite that is toxic to humans. The native recluse spider of California *(L. deserta)* is found in the desert regions of southern California and neighboring states. Its bite can cause problems, but it is not as toxic as that of the Chilean recluse. In any case, bites from either species are rare. Both the native desert recluse spider and the Chilean recluse spider occur principally in the drier areas of southern California.

Recluse spiders can have a violin-shaped mark (with the neck of the violin pointing backward) on the top side of the head region (cephalothorax). However, the mark is not always distinct, so it should not be used as an identifying character. A unique feature of recluse spiders is their six eyes, arranged in pairs in a semicircle (Fig. 4),

Spider Bites

Unlike mosquitoes, spiders do not seek people in order to bite them. Generally, a spider doesn't try to bite a person unless it has been squeezed, lain on, or similarly provoked to defend itself. Moreover, the jaws of most spiders are so small that the fangs cannot penetrate the skin of an adult person. Sometimes when a spider is disturbed in its web, it may bite instinctively because it mistakenly senses that an insect has been caught.

The severity of a spider bite depends on factors such as the kind of spider, the amount of venom injected, and the age and health of the person bitten. A spider bite might cause no reaction at all, or it might result in varying amounts of itching, redness, stiffness, swelling, and pain—at worst, usually no more severe than a bee sting. Typically the symptoms persist from a few minutes to a few hours. Like reactions to bee stings, however, people vary in their responses to spider bites, so if the bite of any spider causes an unusual or severe reaction, such as increasing pain or extreme swelling, contact a physician, hospital, or poison control center (in California, the number is 1-800-876-4766 or 1-800-8-POISON).

Sometimes a person may not be aware of having been bitten until pain and other symptoms begin to develop. Other species of arthropods whose bites or stings may be mistaken for that of a spider include ticks, fleas, bees, wasps, bedbugs, mosquitoes, the conenose (kissing) bug *(Triatoma protracta)*, deer flies, horse flies, and water bugs *(Lethocerus* spp.).

For first aid treatment of a spider bite, wash the bite, apply an antiseptic to prevent infection, and use ice or ice water to reduce swelling and discomfort. If you receive a bite that causes an unusual or severe reaction, contact a physician. If you catch the critter in the act, capture it for identification, preserve it (or whatever parts of it remain), and take it to your county UC Cooperative Extension office. If no one there can identify it, ask that it be forwarded to a qualified arachnologist.

which can be seen with the use of a good hand lens. Most other spiders have eight eyes.

All recluse spiders make large, irregular, flattened, cobweb-type webs with thick strands extending in all directions. These spiders avoid light, are active at night, and tend to build their webs in out-of-the-way places. Chilean recluse spiders may be found indoors in boxes, in corners, behind pictures, in old clothing hanging undisturbed, and in other similar places. Desert recluse spiders appear outdoors where they may be found under rocks or wood.

A person bitten by a recluse spider may not be aware of having been bitten at the time of the bite. The first symptoms often appear several hours later. They consist of pain, formation of a small blister, redness, and swelling at the bite site. In the days following the initial bite, the tissue dies and sloughs off, exposing underlying flesh. The area develops into an open sore that is very slow to heal and may leave a sunken scar after healing. There may be accompanying flulike effects such as nausea, fever, chills, and restlessness. Bites from brown recluse spiders have never been confirmed in California. More detailed information on these spiders is available in *Pest Notes: Brown Recluse and Other Recluse Spiders*, listed in the "Suggested Reading" section.

Other Spiders

In addition to the species mentioned above, there are only a few other species of spiders in California that may on occasion bite humans. (Remember, if the bite of any spider causes an unusual or severe reaction, contact a physician.)

One kind of **red and black jumping spider**, *Phidippus johnsoni,* may bite if it is disturbed, but the bites are usually not serious. The female spiders are black with red on the top side of the abdomen whereas the males are all red. These spiders range in size from 1/4 to 1/2 inch long.

Tarantulas are long-lived spiders that occupy burrows in the ground during the day but often come out at night to hunt insects near the burrow. They commonly are feared because of their large size and hairy appearance. Some poisonous tarantulas occur in tropical parts of the world, but the bites of California tarantulas are not likely to be serious—at worst, they are similar to a bee sting.

The **hobo spider**, *Tegenaria agrestis*, also called the aggressive house spider, is a common spider in the Pacific Northwest. It builds funnel-shaped webs in dark, moist areas such as basements, window wells, wood piles, and around the perimeter of homes. It is a large (1 to 1 3/4 inch, including legs), fast-running brown spider with a herringbone or multiple chevron pattern on the top of the abdomen.

Bites most commonly occur when a person picks up firewood with a spider on it or when a spider finds its way into clothing or bedding. Reactions to bites of the hobo spider are similar to those caused by brown recluse spiders. The major difference between the two is that sometimes the bite of the hobo spider is accompanied by a severe headache that does not respond to aspirin. The hobo spider has not been documented in California, but it has been documented as expanding its range into other states that border Washington and Oregon.

One spider frequently found indoors is the **common house spider**, *Achaearanea tepidariorum* (Fig. 5), which makes a cobweb in corners of rooms, in windows, and in similar places. Another is the **marbled cellar spider**, *Holocnemus pluchei*, which was introduced into the state in the 1970s and has since displaced the once common **longbodied cellar spider**, *Pholcus phalangioides* (Fig. 6), a longlegged spider that resembles a daddy-longlegs. These spiders are incapable of biting humans because their fangs are too short to pierce people's skin; they primarily cause problems by producing messy cobwebs.

Various kinds of small hunting spiders may wander indoors and occasionally, rather large, hunting-type spiders are discovered in homes or garages. Often these are fully grown wolf spider or tarantula males that have reached maturity and are searching for females. When these spiders are wandering, one

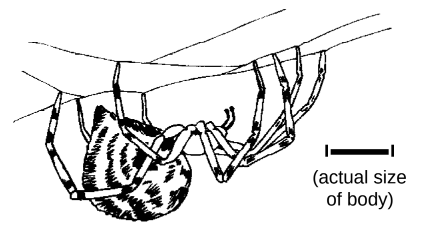

Figure 5. Adult common house spider.

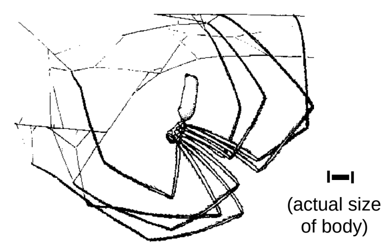

Figure 6. Adult longbodied cellar spider.

or more may accidentally get indoors. New houses and other structures in developments may be invaded by wolf spiders that have lost their usual outdoor living places. The more insects there are inside a building, the more likely it is to have spiders living there. Usually spiders are most abundant in fall following the first few rains of the season. Immature and adult female burrow-living spiders sometimes wander for a time during the rainy season if they have had to abandon wet burrows.

MANAGEMENT

Remember that spiders are primarily beneficial and their activities should be encouraged in the garden. Pesticide control is difficult and rarely necessary. The best approach to controlling spiders in and around the home is to remove hiding spots for reclusive spiders such as black widows and regularly clean webs off the house with brushes and vacuums.

Prevention and Nonchemical Control

Spiders may enter houses and other structures through cracks and other openings. They also may be carried in on items like plants, firewood, and boxes. Regular vacuuming or sweeping of windows, corners of rooms, storage areas, basements, and other seldomly used areas helps remove spiders and their webs. Vacuuming spiders can be an effective control technique because their soft bodies usually do not survive this process. Indoors, a web on which dust has gathered is an old web that is no longer being used by a spider.

Individual spiders can also be removed from indoor areas by placing a jar over them and slipping a piece of paper under the jar that then seals off the opening of the jar when it is lifted up.

To prevent spiders from coming indoors, seal cracks in the foundation and other parts of the structure and gaps around windows and doors. Good screening not only will keep out many spiders but also will discourage them by keeping out insects that they must have for food.

In indoor storage areas, place boxes off the floor and away from walls, whenever possible, to help reduce their usefulness as a harborage for spiders. Sealing the boxes with tape will prevent spiders from taking up residence within. Clean up clutter in garages, sheds, basements, and other storage areas. Be sure to wear gloves to avoid accidental bites.

Outdoors, eliminate places for spiders to hide and build their webs by keeping the area next to the foundation free of trash, leaf litter, heavy vegetation, and other accumulations of materials. Trimming plant growth away from the house and other structures will discourage spiders from first taking up residence near the structure and then moving indoors. Outdoor lighting attracts insects, which in turn attracts spiders. If possible, keep lighting fixtures off structures and away from windows and doorways. Sweep, mop, hose, or vacuum webs and spiders off buildings regularly. Insecticides will not provide long-term control and should not generally be used against spiders outdoors.

Chemical Control

Typically pesticide control of spiders is difficult unless you actually see the spider and are able to spray it. There are various insecticides available in retail outlets labeled for spider control, including pyrethrins, resmethrin, allethrin, or combinations of these products. Avoid products containing chlorpyrifos or diazinon because they have been implicated in storm water contamination. If you spray a spider, it will be killed only if the spray lands directly on it; the spray residual does not have a long-lasting effect. This means a spider can walk over a sprayed surface a few days (and in many cases, a few hours) after treatment and not be affected. Control by spraying is only temporary unless accompanied by housekeeping. It is just as easy and much less toxic to crush the spider with a rolled up newspaper or your shoe or to vacuum it up.

Sorptive dusts containing amorphous silica gel (silica aerogel) and pyrethrins, which can be applied by professional pest control applicators only, may be useful in certain indoor situations. Particles of the dust affect the outer covering of spiders (and also insects) that have crawled over a treated surface, causing them to dry out. When applied as a dustlike film and left in place, a sorptive dust provides permanent protection against spiders. The dust is most advantageously used in cracks and crevices and in attics, wall voids, and other enclosed or unused places.

COMPILED FROM:

Barr, B. A., G. W. Hickman, and C. S. Koehler. 1984. *Spiders*. Oakland: Univ. Calif. Div. Agric. Nat. Res. Leaflet 2531.

SUGGESTED READING

Akre, R. D., and E. P. Catts. 1992. *Spiders.* Pullman: Wash. State Univ., Cooperative Extension Publ. EB1548.

Hedges, S. A., and M. S. Lacey. 1995. *Field Guide for the Management of Urban Spiders.* Cleveland: Franzak and Foster Co.

Marer, P. 1991. *Residential, Industrial, and Institutional Pest Control.* Oakland: Univ. Calif. Div. Agric. Nat. Res. Publ. 3334.

Vetter, R. S. Jan. 2000. *Pest Notes: Brown Recluse and Other Recluse Spiders*. Oakland: Univ. Calif. Div. Agric. Nat. Res. Publ. 7468. Also available online at: *http://www.ipm.ucdavis.edu/PMG/selectnewpest.home.html*

For more information contact the University of California Cooperative Extension or agricultural commissionerÕs office in your county. See your phone book for addresses and phone numbers.

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To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

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TERMITES

Integrated Pest Management in and around the Home

Termites are small, white, tan, or black insects that can cause severe destruction to wooden structures. Termites belong to the insect order Isoptera, an ancient insect group that dates back more than 100 million years. The Latin name Isoptera means "equal wing" and refers to the fact that the front set of wings on a reproductive termite is similar in size and shape to the hind set.

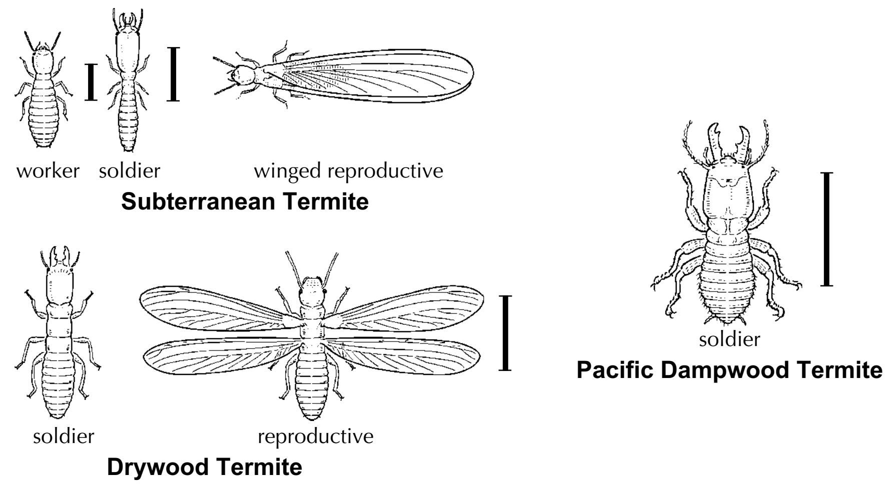

Figure 1. Subterranean, drywood, and dampwood termites.

Although many people think termites have only negative impacts, in nature they make many positive contributions to the world's ecosystems. Their greatest contribution is the role they play in recycling wood and plant material. Their tunneling efforts also help to ensure that soils are porous, contain nutrients, and are healthy enough to support plant growth. Termites are very important in the Sahara Desert where their activity helps to reclaim soils damaged by drying heat and wind and the overgrazing by livestock.

Termites become a problem when they consume structural lumber. Each year thousands of housing units in the United States require treatment for the control of termites. Termites may also damage utility poles and other wooden structures. Termite pests in California include drywood, dampwood, and subterranean species. These pests cause serious damage to wooden structures and posts and may also attack stored food, books, and household furniture.

IDENTIFICATION

Termites are social and can form large nests or colonies, consisting of very different looking individuals (castes).

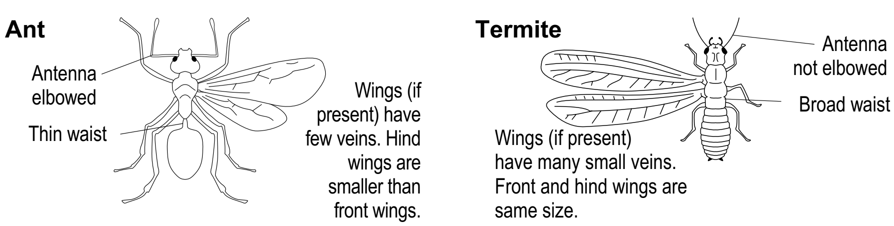

Figure 2. Distinguishing features of ants and termites.

Physically the largest individual is the queen. Her function is to lay eggs, sometimes thousands in a single day. A king is always by her side. Other individuals have large heads with powerful jaws, or a bulblike head that squirts liquid. These individuals are called soldiers. But the largest group of termites in a colony is the workers. They toil long hours tending the queen, building the nest, or gathering food. While other species of social insects have workers, termites are unique among insects in that workers can be male or female. Surprisingly, termites can be long-lived: queens and kings can live for decades while individual workers can survive for several years.

Signs of termite infestation include swarming of winged forms in fall and spring and evidence of tunneling in wood. Darkening or blistering of wooden structural members is another indication of an infestation; wood in

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damaged areas is typically thin and easily punctured with a knife or screwdriver.

There are more than 2,500 different types of termites in the world and at least 17 different types of termites in California. However, most of this diversity can be lumped into four distinct groups: dampwood, drywood, subterranean, and mound builders. Mound builders do not occur in North America, but the other three species do (Fig. 1). Dampwood termites are very limited in their distribution: most species are found only in California and the Pacific Northwest. Dampwood termites derive their name from the fact that they live and feed in very moist wood, especially in stumps and fallen trees on the forest floor. Drywood termites are common on most continents and can survive in very dry conditions, even in dead wood in deserts. They do not require contact with moisture or soil. Subterranean termites are very numerous in many parts of the world and live and breed in soil, sometimes many feet deep. Lastly, the mound builders are capable of building earthen towers 25 feet or more in height. Mounds may be located either in the soil or in trees, and where they occur in Africa, Australia, Southeast Asia, and parts of South America, they are very noticeable and remarkable.

Termites are sometimes confused with winged forms of ants, which also leave their underground nests in large numbers to establish new colonies and swarm in a manner similar to that of reproductive stages of termites. However, ants and termites can be distinguished by checking three features: antennae, wings, and waist (Fig. 2).

Dampwood Termites

Dampwood termites are fairly common in central and northern coastal areas in California. They nest in wood buried in the ground, although contact with the ground is not necessary when infested wood is high in moisture. Because of their high moisture requirements, dampwood termites most often are found in cool, humid areas along the coast and are typical pests of beach houses. Winged reproductives typically swarm between July and October, but it is not unusual to see them at other times of the year. Dampwood termite winged reproductives (sometimes called swarmers) are attracted to lights.

Dampwood termites produce distinctive fecal pellets that are rounded at both ends, elongate, and lack the clear longitudinal ridges common to drywood termite pellets (Fig. 3). Final confirmation of pellet identification may require help from an expert.

The Nevada dampwood termite, *Zootermopsis nevadensis*, occurs in the higher, drier mountainous areas of the Sierras where it is an occasional pest in mountain cabins and other forest structures; it also occurs along the northern California coast. The Pacific dampwood termite, *Zootermopsis angusticollis*, is almost one inch long, making it the largest of the termites occurring in California. Winged reproductives are dark brown with brown wings. Soldiers have a flattened brown or yellowish brown head with elongated black or dark brown mandibles. Nymphs are cream colored with a characteristic spotted abdominal pattern caused by food in their intestines. Nevada dampwood termites are slightly smaller and darker than the Pacific species; reproductives are about ¾ inch long.

Drywood Termites

Drywood termites infest dry, undecayed wood, including structural lumber as well as dead limbs of native trees and shade and orchard trees, utility poles, posts, and lumber in storage. From these areas, winged reproductives seasonally migrate to nearby buildings and other structures usually on sunny days during fall months. Drywood termites are most prevalent in southern California (including the desert areas), but also occur along most coastal regions and in the Central Valley.

Drywood termites have a low moisture requirement and can tolerate dry conditions for prolonged periods. They remain entirely above ground and do not connect their nests to the soil. Piles of their fecal pellets, which are distinctive in appearance, may be a clue to their presence. The fecal pellets are elongate (about 3/100 inch long) with rounded ends and have six flattened or roundly depressed surfaces separated by six longitudinal ridges (see Fig. 3). They vary considerably in color, but appear granular and salt and pepperlike in color and appearance.

Winged adults of western drywood termites *(Incisitermes minor)* are dark brown with smoky black wings and have a reddish brown head and thorax; wing veins are black. These insects are noticeably larger than subterranean termites.

Subterranean Termites

Subterranean termites require moist environments. To satisfy this need, they usually nest in or near the soil and maintain some connection with the soil through tunnels in wood or through shelter tubes they construct (Fig. 4). These shelter tubes are made of soil with bits of wood or even plasterboard (drywall). Much of the damage they cause occurs in foundation and structural support wood. Because of the moisture requirements of subterranean termites, they are often found in wood that has wood rot.

The western subterranean termite, *Reticulitermes hesperus,* is the most destructive termite found in California. Reproductive winged forms of subterranean termites are dark brown to brownish black, with brownish gray wings. On warm, sunny days follow-

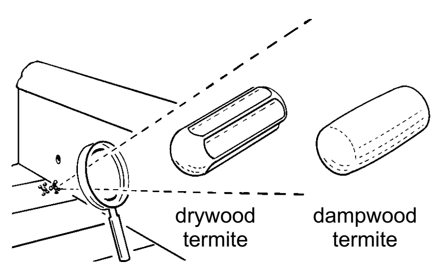

Figure 3. Fecal pellets of drywood and dampwood termites.

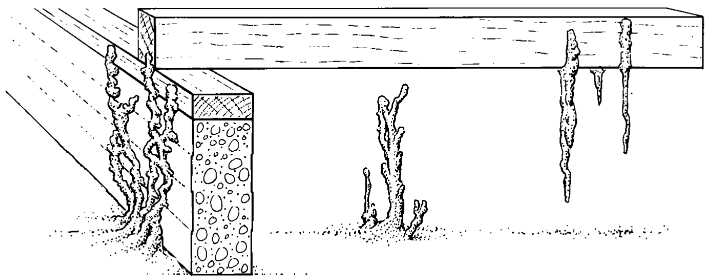

Figure 4. Subterranean termites construct three types of tubes or tunnels. Working tubes (left) are constructed from nests in the soil to wooden structures; they may travel up concrete or stone foundations. Exploratory and migratory tubes (center) arise from the soil but do not connect to wood structures. Drop tubes (right) extend from wooden structures back to the soil.

ing fall or sometimes spring rains, swarms of reproductives may be seen. Soldiers are wingless with white bodies and pale yellow heads. Their long, narrow heads have no eyes. Workers are slightly smaller than reproductives, wingless, and have a shorter head than soldiers; their color is similar to that of soldiers. In the desert areas of California, *Heterotermes aureus*, is the most destructive species of subterranean termites. Another destructive species in this group, the Formosan subterranean termite, *Coptotermes formosanus,* is now in California but restricted to a small area near San Diego. Unlike the western subterranean termite, Formosan subterranean termites swarm at dusk and are attracted to lights.

LIFE CYCLE

Most termite species swarm in late summer or fall, although spring swarms are not uncommon for subterranean and drywood termites. New kings and queens are winged during their early adult life but lose their wings after dispersing from their original colony. An infestation begins when a mated pair finds a suitable nesting site near or in wood and constructs a small chamber, which they enter and seal. Soon afterward, the female begins egg laying, and both the king and queen feed the young on predigested food until they are able to feed themselves. Most species of termites have microscopic, one-celled animals called protozoa within their intestines that help in converting wood (cellulose) into food for the colony.

Once workers and nymphs are produced, the king and queen are fed by the workers and cease feeding on wood. Termites go through incomplete metamorphosis with egg, nymph, and adult stages. Nymphs resemble adults but are smaller and are the most numerous stage in the colony. They also groom and feed one another and other colony members.

MANAGEMENT

Successful termite management requires many special skills, including a working knowledge of building construction. An understanding of termite biology and identification can help a homeowner detect problems and understand methods of control. In most cases it is advisable to hire a professional pest control company to carry out the inspection and control program.

Management techniques vary depending on the species causing an infestation. Multiple colonies of the same species of termite or more than one species of termite can infest a building (Fig. 5). Any of these variables will influence your control approach. Subterranean, and less frequently, dampwood termites can have nests at or near ground level, so control methods for these can be similar. However, drywood termites nest above ground, therefore the approach for eliminating them is unique.

Use an integrated program to manage termites. Combine methods such as modifying habitats, excluding termites from the building by physical and chemical means, and using mechanical and chemical methods to destroy existing colonies.

Inspection

Before beginning a control program, thoroughly inspect the building. Verify that there are termites, identify them, and assess the extent of their infestation and damage. Look for conditions within and around the building that promote termite attack, such as excessive moisture or wood in contact with the soil. Because locating and identifying termite species is not always easy, it may be advisable to have a professional conduct the inspection.

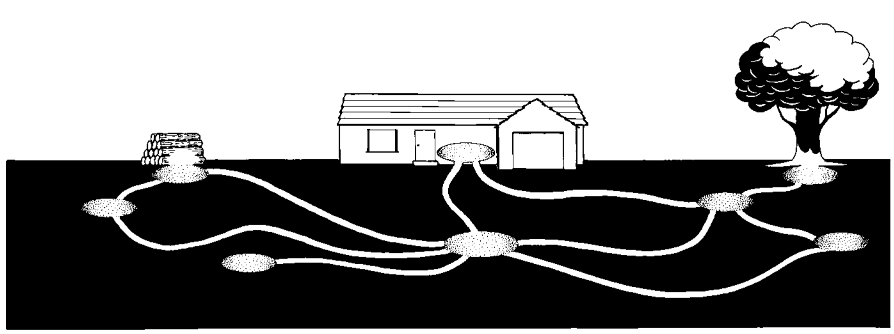

Figure 5. Subterranean termite colony with multiple nesting sites.

Table 1. Relative Resistance of Lumber to Termites[1]

Moderately or very resistant	Moderately resistant	Slightly resistant or nonresistant
Arizona cypress	bald cypress (young growth)	alder
bald cypress (old growth)	Douglas fir	ashes
black cherry	eastern white pine	aspens
black locust	honey locust	basswood
black walnut	loblolly pine	beech
bur oak	longleaf pine	birches
catalpa	shortleaf pine	black oak
cedars	swamp chestnut oak	butternut
chestnut	tamarack	cottonwood
chestnut oak	western larch	elms
gambel oak		hemlocks
junipers		hickories
mesquite		maples
Oregon white oak		pines
osage orange		poplars
Pacific yew		red oak
post oak		spruces
red mulberry		true firs
redwood		
sassafras		
white oak		

Adapted from: *Wood Handbook: Wood as an Engineering Material.* USDA Agriculture Handbook No. 72.

[1] The heartwood of the tree offers the greatest resistance to termite attack.

Prevention

Building design may contribute to termite invasion. Keep all substructural wood at least 12 inches above the soil beneath the building. Identify and correct other structural deficiencies that attract or promote termite infestations. Stucco siding that reaches the ground promotes termite infestations. Keep attic and foundation areas well ventilated and dry. Use screening over attic vents and seal other openings, such as knotholes and cracks, to discourage the entry of winged drywood termites. Although screening of foundation vents or sealing other openings into the substructure helps block the entry of termites, these procedures may interfere with adequate ventilation and increase moisture problems, especially if a very fine mesh is used in the screening. Inspect utility and service boxes attached to the building to see that they are sealed and do not provide shelter or a point of entry for termites. Reduce chances of infestation by removing or protecting any wood in contact with the soil. Inspect porches and other structural or foundation wood for signs of termites. Look for and remove tree stumps, stored lumber, untreated fence posts, and buried scrap wood near the structure that may attract termites. Consult your local city building codes before beginning repairs or modifications.

Recent research has proved the effectiveness of foundation sand barriers for subterranean termite control. Sand with particle sizes in the range of 10 to 16 mesh is used to replace soil around the foundation of a building and sometimes in the crawl space. Subterranean termites are unable to construct their tunnels through the sand and therefore cannot invade wooden structures resting on the foundation. Stainless steel screening may also be available soon as a physical barrier for subterranean termites.

Replacing Lumber in Structures. Structural lumber in buildings is usually Douglas fir, hemlock, or spruce. Of these materials, Douglas fir is moderately resistant to termites, whereas the other two are not (Table 1). Lumber used in foundations and other wood in contact with the soil may be chemically treated to help protect against termite damage in areas where building designs must be altered or concrete cannot be used.

The most effective method of chemically treating wood is through pressure treatment. Chemicals currently used in pressurized treatments include chromated copper arsenate (CCA), ammoniacal copper zinc arsenate (ACZA), disodium octoborate tetrahydrate (DOT), and wolman salts (sodium fluoride, potassium bichromate, sodium chromate, and dinitrophenol). Wood containing CCA is tinted green and ACZA is brownish. DOT (borate) is clear in appearance on the wood surface when used at labeled amounts. Borates are gaining in popular usage because of their low mammalian toxicity.

Many of the chemicals used in pressurized lumber can also be applied topically to the wood by brushing or spraying it on. Pressure treatment is preferred over topical application because the chemical penetrates the lumber much deeper (1/4 to 1/2 inch) than it does when applied by brush or spray. Some of the more porous lumbers such as the southern yellow pines (loblolly–*Pinus taeda*; longleaf–*P. palustris*; and shortleaf–*P. echinata*) may be completely penetrated by the chemical during the pressurized process. Topical applications are most effective when used as spot treatments on pressure-treated lumber to treat newly exposed wood when the lumber is cut and drilled during construction.

Pressure-treated lumber is toxic to termites and discourages new kings and queens from establishing colonies in it. If susceptible wood is used above the treated wood, however, subterranean termites can build their shelter tubes over chemically treated wood and infest untreated wood above.

Use only "exterior grade" pressure-treated lumber for areas that are exposed to weather; otherwise the chemical in the lumber may leach from the wood. All topical treatments, especially borates, that will be exposed to weather, must also have a sealer coat to prevent leaching into the soil following rain. Because they contain pesticides, disposal of treated lumber requires special handling. For more information on proper disposal of treated lumber, contact your local Household Hazardous Waste Collection site. For the site nearest you, call 1-800-253-2687.

Treating Lumber in Structures. Treating infested lumber in a structure requires drilling and injecting chemicals into the wood to reach the colony. Because of toxicity and complexity of use, most wood preservatives that are applied to wood in a structure are professional-use only.

Controlling Drywood Termites

Drywood termite colonies are usually small and difficult to detect. Treatments for this pest include whole-structure applications of fumigants or heat and localized or spot treatments of chemicals or treatments that use heat, freezing, microwaves, or electricity. Techniques to prevent infestations of this species include the use of chemicals, pressure-treated wood, barriers, and resistant woods. For more details on these control methods and their effectiveness, see *Pest Notes: Drywood Termites*, listed in "Compiled From."

Controlling Subterranean and Dampwood Termites

Subterranean and dampwood termites in structures cannot be adequately controlled by fumigation, heat treatment, freezing, or termite electrocution devices because the reproductives and nymphs are concentrated in nests near or below ground level in structures out of reach of these control methods. The primary methods of controlling these termites are the application of insecticides or baiting programs.

Use of insecticides or baits should be supplemented with the destruction of their access points or nests. To facilitate control of subterranean termites, destroy their shelter tubes whenever possible to interrupt access to wooden substructures and to open colonies to attack from natural enemies such as ants. For dampwood termites, if infestations are small, destroy accessible nests by removing infested wood. Removing excess moisture from wood will also destroy dampwood termite nests.

Insecticides. Insecticides are applied to the soil either in drenches or by injection. Special hazards are involved with applying insecticides to the soil around and under buildings and a licensed professional does these procedures best. Applications in the wrong place can cause insecticide contamination of heating ducts, radiant heat pipes, or plumbing used for water or sewage under the treated building. Soil type, weather, and application techniques influence the mobility of insecticides in the soil; soil-applied insecticides must not leach through the soil profile to contaminate groundwater.

In the past, chlorinated hydrocarbon insecticides (e.g., chlordane) and organophosphates (chlorpyrifos) were extensively used for termite control but many of these materials have been phased out because of health and environmental concerns. Active ingredients in currently available termiticides can be broadly classified as repellent or nonrepellent. Pyrethroids, such as permethrin and cypermethrin (Dragnet and Demon), are considered to be repellent. This means that the termites are able to detect the insecticide, which basically serves as a barrier, and they are repelled by it without receiving a dose that will kill them. Therefore, when using these materials it is important to make sure there are no gaps or breaches in the barrier. Also, any adjoining structures must be monitored to ensure that the repelled termites don't infest them.

Recently introduced chemicals (imidacloprid and fipronil) are now available that are less toxic to humans and other mammals than the older insecticides but highly toxic to insects. Both of these insecticides are also nonrepellent to termites and have been shown to be effective in killing termites at low dosage rates under California's climatic conditions. Generally, the most effective insecticides are only available to licensed structural pest control operators.

Baiting. Baits for subterranean termites are commercially available in California. While this method of controlling termites is very appealing because it does not require extensive site preparation such as drilling or trenching and extensive application of insecticide to the soil or structure, research is still ongoing to develop the most effective baits and delivery systems.

Several bait products (e.g., Sentricon with hexaflumuron and FirstLine with sulfluramid) are available for professional use only. There is also an over-the-counter product (Terminate with sulfluramid) available in retail stores. Currently, baits are only available for subterranean termites, not drywood or dampwood termites. Because subterranean termites in California vary in their foraging and in the times that they will take baits, the placement of bait stations and the time of installation is a crucial component in a successful baiting program. Be sure to read and follow all the label directions for the product you use. Once a termite infestation is controlled, it is essential that the bait stations continue to be monitored monthly. Spring is an especially critical time to detect invasion by new colonies.

Other Methods. Experimental efforts have been made to control soil-dwelling termites using biological control agents, including use of Argentine ants and nematodes. However, these methods are not yet effective enough to be recommended.

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Marer, P. 1991. *Residential, Industrial, and Institutional Pest Control.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3334.

REFERENCES

Potter, M. F. 1997. Termites. In A. Mallis, ed. *Handbook of Pest Control*, 8th ed. Cleveland: Franzak & Foster Co.

Scheffrahn, R. H., N.-Y. Su and P. Busey. 1997. Laboratory and field evaluations of selected chemical treatments for control of drywood termites (Isoptera: Kalotermitidae). *J. Econ. Entomol.* 90: 492-502.

Online References

California:
CAL Termite Web page, www.cnr.berkeley.edu/lewis

International:
UNEP/FAO/Global IPM Facility Workshop on Termite Biology and Management, www.chem.unep.ch/pops/pdf/termrpt.pdf

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

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WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

DRYWOOD TERMITES

Integrated Pest Management in the Home

The western drywood termite, *Incisitermes minor* (Fig. 1), is California's second most important termite pest after the western subterranean termite. It is a native insect that has been here millions of years, mostly attacking trees along river washes and arroyos. In California drywood termites are most prevalent in southern California and the Central Valley but also can be found infesting wood along the coast, in bay areas south of San Francisco, and in the southern California desert. For more information on the biology and distinguishing characteristics of this and other termite species common in California, see *Pest Notes: Termites,* listed in References.

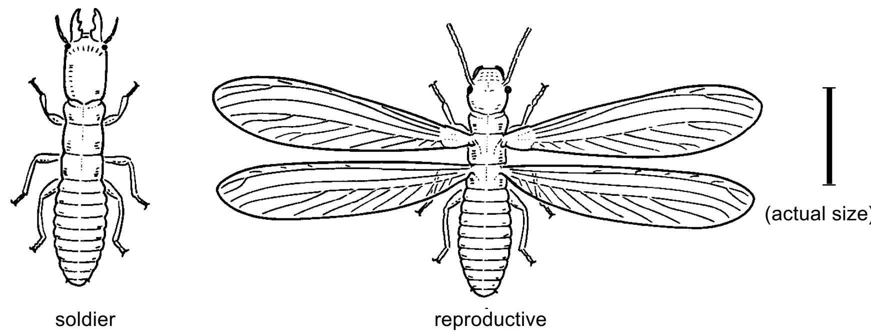

Figure 1. Western drywood termite.

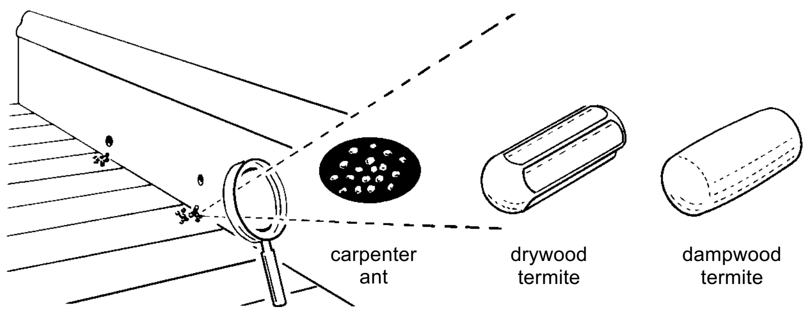

Figure 2. The fecal pellets produced by drywood termites are elongate with rounded ends and have six flattened or roundly depressed surfaces separated by six longitudinal ridges.

Because of the difficulty in detecting drywood termites and determining the extent of the damage done, do-it-yourself treatments are not recommended; consult a pest control professional. Over-the-counter products with drywood termites on the label for do-it-yourself enthusiasts do not exist. Except for wood removal, homeowners should seek help from pest control professionals. This publication is intended to provide homeowners with sufficient background information so that they can better discuss treatment options with pest control professionals; it is not intended as a treatment guide.

DETECTION

Drywood termites are secretive insects and are difficult to detect. They live deep inside wood and, except during periods when they swarm or when repair work is being done on infested homes, they are seldom seen. Colonies are small (usually fewer than 1,000 individuals), can be widely dispersed, and take years to mature. While a homeowner may initially detect the presence of termites when they swarm or if fecal pellets are discovered, inspecting for drywood termites and determining the extent of an infestation require experience.

The minimum requirement by California state law for drywood termite inspections includes visual searches of accessible areas. However, detection of difficult-to-find infestations may require removal of walls, paneling, and stucco as well as the use of ladders and scaffolds.

During a visual inspection for drywood termites, inspectors look for feeding damage, shed wings, termite fecal pellets, and kickout holes (Fig. 2), which are small holes the size of BB shot through which termites push fecal pellets out of the wood. Fecal pellets, hexagonal in shape, are diagnostic for drywood termites. However, whether the infestation is currently active or what the extent of the infestation is cannot be determined from pellets alone. Cleaning up the fecal pellets around a kickout hole and checking a few days later to see if new pellets have appeared can help to determine if an infestation is active. (Building vibrations/movements may cause some pellets to appear.) If an active infestation of drywood termites is found in your structure, you should have it treated.

Other detection methods include the use of dogs, odor detectors, and feeding-sensitive (acoustic emission) devices, but these are infrequently used. Fiber optics, borescopes, and movement-sensitive devices using microwaves have also been tried, but their reliability has not yet been scientifically tested on drywood termites. Except for feeding-sensitive devices, most detection methods are still considered experimental because adequate research has not been conducted on their effectiveness. Visual searches by inspectors for evidence of termites and damage remain the mainstay of the industry.

ELIMINATING EXISTING INFESTATIONS

All drywood termite control methods can be categorized as either whole-structure or localized. A whole-structure treatment is defined as the simultaneous treatment of all infestations, accessible and inaccessible, in a structure. A localized or spot treatment is more restrictive, often applied to a single board or small group of boards. Homeowners are advised to know the distinction between whole-structure and spot treatments when deciding which method to select because all treatment methods are not equivalent.

Whole-structure treatments have an advantage over spot treatments in that they can eliminate all infestations, even hidden ones. With the uncertainty of current detection methods, particularly when drywall or other wall coverings conceal infestations, there is always some doubt as to the extent of drywood termite colony boundaries within homes. Consequently one can never be sure that all infestations have been treated when applying spot treatments. The strengths and limitations of whole-structure and spot/localized treatments are outlined in Table 1.

Whole-structure Treatment

Fumigants (sulfuryl fluoride) treat all infestations simultaneously and have high levels of efficacy if correctly applied. Sulfuryl fluoride kills drywood termites in about 3 days. A monitored fumigation, which involves installing gas monitoring lines inside the structure undergoing treatment, has the highest rate of treatment success. Nonmonitored fumigation may not have enough gas concentration to kill infestations, and failures may occur. Fumigation's advantage over localized treatment is that it may eliminate infestations that are hidden from view. Major issues to consider with the use of fumigants include the difficulty of installing tarpaulins, the difficulty in determining the proper dosage, the need to protectively bag food items, and the lack of residual control. Residual control means long-term protection (several years or more) from drywood termite attack. (Generally, only chemicals added to or onto wood provide residual control.) It will also be necessary to vacate the structure for 2 to 3 days while it is being treated and then ventilated. Additionally, roofs may be damaged by having tarpaulins dragged across them.

Methyl bromide was another fumigant used for many decades in California to control drywood termites. However, because of environmental concerns about the atmospheric ozone layer, the strong odors of some formulations, the long aeration times for fumigated structures, and the need for extensive aeration buffer areas around structures, this fumigant has been phased out for urban use in California.

Heat is a nonchemical option for whole-structure treatments. Excessive heat kills drywood termites by disrupting cellular membranes and denaturing enzymes needed for their survival. The treatment process involves heating all wood in the structure to a minimum of 120°F and holding this temperature for at least 33 minutes. The benefit of heat treatment is the ability to treat the entire structure without the use of chemicals and the relatively short period of time the structure must be vacated (hours instead of days, as with the use of fumigants). An additional advantage is that portions of large structures can be treated separately, which is very useful in apartments and condominiums. The major drawbacks of heat treatments include the difficulty in raising the internal core temperature of large structural beams that are infested and heat sinks, which are areas within the structure that are difficult to heat, such as wood on concrete or tile. As more powerful and efficient heaters are developed, larger homes can be efficiently treated with heat.

Other issues to consider include damage to heat-sensitive items in homes including plastics (e.g. electrical outlet covers) and cable wiring. Also, like fumigants, heat treatments have no residual control. Of course, preventive chemicals can be applied to areas treated with fumigants or heat for long-term protection (see preventive section in Table 1).

Localized or Spot Treatments

There are many localized/spot treatment methods available (Table 1) that include both chemical and nonchemical options. The **chemical options** include aerosol pyrethrum and aerosol and liquid pyrethroids (cyfluthrin, permethrin, bifenthrin), liquid imidacloprid, liquid nitrogen, and liquid and dust formulations of disodium octaborate tetrahydrate. Chemicals that have been phased out of commercial use include organophosphates, carbamates, silica-gel, and dri-die. For liquid and dust insecticides to be effective, termites must touch or ingest them. Spot treatments should be applied only by licensed applicators. Home use products are not effective.

Depending on the chemical used for spot treatments, laboratory studies have shown a variation of 13% to 100%

TABLE 1. Summary of Commercially Available Drywood Termite Management Options.

Treatment	Efficacy in field	Strengths	Considerations/Limitations	Damage to structure
EXISTING INFESTATIONS				
Whole-structure				
Fumigants	up to 100% [1, 2, 3]	hidden sites treated	correct dosage must be achieved; residents must leave house; no residual	gas pilots must be extinguished before treatment; possible damage to roof from tarpaulins or if walked on
Heat	up to 100% [2]	hidden sites treated	lethal temperature must be achieved in the core of all infested wood; no residual; heat sinks may affect efficacy	possible damage to roof if walked on and for some heat-sensitive household items
Localized/Spot treatments				
Chemical				
Chemical liquids & dusts	up to 90% [3]	long-term	few active ingredients commercially available; detection accuracy critical; chemical residual; results vary with active ingredient used and concentration; infestation may rebound	yes, if drill holes used
Chemical foams	no information	coverage of hidden infestation, long-term	no published efficacy studies	yes, drilling holes
Liquid nitrogen	74 to 100% [2]	benign material	highly dependent on dosage; detection accuracy critical; no residual	yes, drill holes
Nonchemical				
Biological control	no information	no chemicals	few commercially available; research needed	don't know
Electrocution	44 to 98% [2]	portable	detection accuracy critical; many disclaimers; infestation may rebound	yes, if drill holes used
Heat	up to 100% [2]	semi-portable	lethal temperature must be achieved in the core of all infested wood; no residual; heat sinks may affect efficacy	may be to wood or heat-sensitive household items
Microwaves	89 to 98% [2]	semi-portable	detection accuracy critical; highly dependent on treatment time and wattage; heat sinks may affect efficacy	may be to wood or household items
PREVENTIVE				
Chemical liquids & dusts	up to 90% [3]	long-term	few active ingredients available; chemical residual; results vary depending on active ingredient used and concentration; infestation may rebound	yes, if drill holes used
Pressure-treated wood	no information	long-term	few active ingredients commercially available; chemical residual; results vary with active ingredient used and concentration; environmental persistence	no
Nonchemical				
Barriers (screens/paint)	no information	long-term	barriers degrade & can be breached; some feeding damage may occur	no
Resistant woods	no information	long-term	efficacy highly variable depending on species of wood; costly; availability; some feeding damage may occur	no

1 - Su & Scheffrahn 1986; 2 - Lewis & Haverty 1996; 3 - Scheffrahn et al. 1997

in their effectiveness in controlling drywood termites. However, many of these chemicals have not been tested in large-scale field-tests. A newer insecticide (imidacloprid) with very good lab and field results is available and will be used increasingly in California. Botanical-based products (orange oil and neem oil) have been tried, but there are no published studies that verify the efficacy of these materials in controlling drywood termites. Recent experiments evaluating surface or gallery injections of aqueous disodium octaborate tetrahydrate did not effectively control a closely related species of drywood termites, *Incisitermes synderi* (Scheffrahn et al. 1997).

Liquid nitrogen is different from other spot treatment methods in that its mode of action is thermal; it causes a sudden drop in temperature, which kills the termites. Laboratory studies have shown drywood termites are killed after momentary exposures of temperatures in the range of -5.8°F to 1.4°F when temperatures were lowered from room temperature at a rate of 33.8°F per minute (Rust et al. 1997). Studies on liquid nitrogen show that dosages exceeding 30 pounds per enclosed wall space between 2 by 4s achieve high levels of effectiveness. Although most chemicals used for spot treatments give long-term control, liquid nitrogen has no residual activity when used alone. Minor damage to the structure occurs from the holes drilled for spot treatments of chemicals and for liquid nitrogen insertion. For all chemical spot treatments, including liquid nitrogen, it is critical that all infestations in a structure are detected so that they all receive treatment.

There are four **nonchemical options** for drywood termite control with spot or localized application (Table 1), including *heat*, which is used for both spot and whole-structure treatments. The advantages and disadvantages discussed for heat as a whole-structure treatment also apply to spot treatments. *Microwave* devices are also available for drywood termite control. Microwaves kill termites by causing fluids inside their cells to boil, which destroys cell membranes; in short, the termites are cooked inside the wood. There are a number of firms now offering microwave treatments. One advantage of microwaves is their relative portability; another advantage is that they leave no chemical residue. When using microwaves, however, detection accuracy is critical to success. Both microwaves and heat treatments may damage the surface or interior of wood boards, depending on the power of the device. (The wattage or power of microwave or heating devices may vary from several hundred to more than 10,000 watts.) Lab studies revealed no relationship between increasing microwave wattage and drywood termite mortality (Lewis et al. 2000). As with heat treatments, it may be difficult to heat areas with heat sinks to high enough temperatures with microwaves for effective control.

High voltage electricity, or *electrocution*, is another nonchemical option for controlling drywood termites. The device currently marketed uses high voltage (90,000 volts) but low current (less than 0.5 amps). Death to drywood termites occurs by electric shock, although delayed mortality may also occur from the destruction of intestinal protozoa. The advantage of electrocution is that the equipment is portable. The limitations include detection accuracy and the possible reduced efficacy from the interfering actions of common building materials, for example metal, concrete, and glass. If drill holes are used to enhance the flow of current into wood, damage occurs to wall coverings, walls, and structural wood members.

Wood replacement is another remedial treatment option. However, similar to other spot treatments, its effectiveness is highly dependent on detection accuracy and extent and location of the infestation, and it may be expensive to accomplish.

There is little research on biological control of drywood termites. Biological control is the use of other life forms (e.g., insects, nematodes, or microbes) to control pest insects. Although predators, parasites, and pathogens have been shown to control other insect pests, their efficacy for drywood termite control has not been explored.

LONG-TERM PREVENTIVE TREATMENTS

Although chemicals are commercially available in California for long-lasting prevention against infestation, there is little data on their effectiveness against the drywood termites that occur in California. Recent research from the University of Florida demonstrates that new colony establishment by another species of drywood termite, *Cryptotermes brevis*, could be prevented using dust formulations of commercially available disodium octaborate tetrahydrate (Scheffrahn et al. 2001). Drawbacks with some chemical preventive treatments include damage from drill holes and unsightly appearance from dusts.

Pressure-treated wood (chemically treated wood that is green in color) for drywood termite prevention can be effective for species that occur in California. However, the use of most wood preservatives has been restricted. Painting of wood with enamel, shellac, or varnish gives very little protection against drywood termite feeding.

Integrating nonchemical and chemical treatments to ensure that termites are not able to colonize over the long term is a strategy used by some pest control professionals. Nonchemical, long-term preventive methods include physical barriers, such as metal screens. Resistant woods can reduce but do not eliminate damage. There are few studies that demonstrate the efficacy of combinations of methods or of nonchemical, long-term preventive treatments directed against drywood termites.

DID I MAKE THE RIGHT CHOICE?

When planning treatment for drywood termites, consider whether the whole structure is to be treated or just localized areas. Localized/spot treatment methods make it more difficult to ensure complete control because of the difficulty in determining the extent of a drywood termite infestation. There also appears to be considerable variation in effectiveness of various techniques from applicator to applicator. Read your guarantee carefully; you may wish to consider an annual inspection service. Also important is a company's reputation. There are thousands of pest control companies in the state. They don't all have the same services or performance. Obtain at least three vendor bids before you decide. Check the reliability of the vendor by asking for client referrals and check the status of its business license and consumer complaints with the California Department of Consumer Affairs, Structural Pest Control Board, in Sacramento and with your local Better Business Bureau. For added information on safety of chemicals to humans and structures, request the Material Safety Data Sheets or equivalent information for nonchemical control methods from the pest control company.

In summary, research indicates that if you correctly locate the colony and get the chemical or nonchemical treatment directly onto the termites, the effectiveness of control will be high (90%). For failed treatments, an additional callback treatment may lead to better results.

REFERENCES

Lewis, V. R. 1997. Alternative control strategies for termites. *J. Agric. Entomol.* 14: 291-307.

Lewis, V. R., and M. I. Haverty. 1996. Evaluation of six techniques for control of the Western drywood termite (Isoptera: Kalotermitidae) in structures. *J. Econ. Entomol*. 89 (4): 922-934.

Lewis, V. R., A. B. Power, and M. I. Haverty. 2000. Laboratory evaluation of microwaves for control of the western drywood termite. *Forest. Prod. J.* 50: 79-87.

Rust, M. K., and D. A. Reierson. 1977. Using wood extracts to determine the feeding preferences of the western drywood termite, *Incisitermes minor* (Hagen). *J. Chem. Ecol.* 3: 391-399.

Rust, M. K., and R. H. Scheffrahn. 1982. Performance of treated surfaces against western drywood termites. *Insect. Acari.* 7: 234-235.

Rust, M. K., E. O. Paine, and D. A. Reierson. 1997. Evaluation of freezing to control wood-destroying insects (Isoptera, Coleoptera). *J. Econ. Entomol.* 90(5): 1215-1221.

Scheffrahn, R. H., and M. K. Rust. 1983. Drywood termite feeding deterrents in sugar pine and antitermitic activity of related compounds. *J. Chem. Ecol*. 9(1): 39-55.

Scheffrahn, R. H., N.-Y. Su, and P. Busey. 1997. Laboratory and field evaluations of selected chemical treatments for control of drywood termites (Isoptera: Kalotermitidae). *J. Econ. Entomol.* 90(2): 492-502.

Scheffrahn, R. H., N.-Y. Su, J. Krecek, A. V. Liempt, B. Maharajh, and G. S. Wheeler. 1998. Prevention of colony foundation by *Cryptotermes brevis* and remedial control of drywood termites (Isoptera: Kalotermitidae) with selected chemical treatments. *J. Econ. Entomol.* 91(6): 1387-1396.

Scheffrahn, R. H., P. Busey, J. K. Edwards, J. Krecek, B. Maharajh, and N.-Y. Su. 2001. Chemical prevention of colony foundation by *Cryptotermes brevis* (Isoptera: Kalotermitidae) in attic modules. *J. Econ. Entomol*. 94(4): 915-919.

Su, N.-Y., and R. H. Scheffrahn. 1986. Field comparison of sulfuryl fluoride susceptibility among three termite species (Isoptera: Kalotermitidae, Rhinotermitidae) during structural fumigation. *J. Econ. Entomol.* 79(4): 903-908.

UC Statewide IPM Program. July 1997. *Pest Notes: Termites.* Oakland: Univ. Caliv. Agric. Nat. Res. Publ. 7415. Also available online at http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7415.html

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WARNING ON THE USE OF CHEMICALS

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Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

WOOD-BORING BEETLES IN HOMES

Integrated Pest Management in the Home

Wood-boring beetle larvae feed on wood and wood products; adults emerge from larval feeding chambers through round, oblong, or D-shaped exit holes. Adults of some species also bore holes into plaster, plastic, and soft metals.

Many species of wood-boring beetles, especially those in the family Buprestidae (flatheaded or metallic wood borers) or the family Cerambycidae (which includes long-horned beetles and roundheaded wood borers), feed on live trees that are old or weakened or fire- or insect-killed trees but do not attack harvested lumber. They cause problems, however, when they emerge from wood in newly constructed buildings, leaving small circular or oval exit holes in the wood. Infested wood must be kiln-dried before it is used for lumber to avoid these problems. Species of these beetles may also be observed in the home if infested firewood is stored inside; however, they will not attack wood structures or furniture.

Three families of beetles have species of wood borers that invade and damage structural and decorative wood and furniture. These families are the powderpost beetles, deathwatch beetles, and false powderpost beetles.

IDENTIFICATION AND LIFE CYCLES

Powderpost Beetles

Beetles in the family Lyctidae are known as powderpost beetles (Fig. 1). They are so named because larvae leave a fine, dustlike powdered frass (a mixture of feces and food fragments) in their galleries that occasionally falls out of exit holes into small piles on floors or other surfaces. This powdered frass is characteristic of powderpost beetles and helps distinguish them from other typical wood-boring beetles. Lyctids attack hardwoods apparently because these woods have pores into which they can lay eggs; softwoods do not have such pores. Also, the starch content in softwoods is nutritionally low for these beetles. They will attack woods that are very dry (as low as 8% moisture).

Adult lyctids usually range from brownish to reddish in color. Woods most often attacked by this beetle are oak, ash, hickory, mahogany, and walnut; infestations are most likely to occur in wood paneling, molding, window / door frames, plywood, hardwood floors, bamboo articles, and furniture. Infestations may occur if beetles or larvae are brought into a building in furniture or firewood. Sometimes the only sign of infestation may be the tiny, round exit holes made by emerging adult beetles. Once they emerge, the winged adult beetles spread to other wood surfaces where they deposit eggs onto unfinished surfaces or in cracks or other openings. They have a life cycle ranging from 3 months to over 1 year, depending on temperature, humidity, and the nutritional quality of the wood.

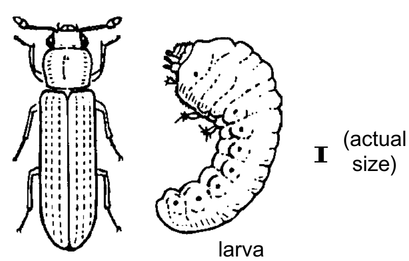

Figure 1. Powderpost beetle.

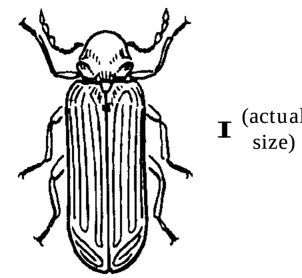

Figure 2. Deathwatch beetle.

Deathwatch Beetles

Wood-boring beetles in the family Anobiidae are known as deathwatch beetles (Fig. 2). Deathwatch beetles are closely related to the drugstore and cigarette beetles, which are stored-product pests. Adults communicate with each other and probably locate mates by tapping their heads against wood, usually at night. (Deathwatch beetles supposedly acquired their name during medieval European times from people who heard the tapping while sitting up with a sick or dying person during the night.) Adults are reddish to dark brown and lay eggs in crevices or small openings or pores in unfinished wood. Two years may be required to complete each generation.

Deathwatch beetles are found primarily in soft woods, including girders, beams, foundation timbers, and some types of furniture. Some species attack books. This beetle is typically found in old wood and may be associated with wood that is partially decayed. Deathwatch beetles prefer wood that is more moist (greater than 14% moisture) than what powderpost beetles prefer and may be less of a problem in houses with central heating and air condition-

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ing. Larvae of deathwatch beetles fill their galleries with small pellets of frass (smaller than the pellets produced by drywood termites), which distinguish them from other wood borers. None of the other boring beetles produce pelletized frass.

False Powderpost Beetles

Wood-boring beetles in the family Bostrichidae are sometimes known as false powderpost beetles (Fig. 3). Larvae tightly pack their galleries with frass that has the consistency of coarse powder; this coarse texture distinguishes them from true powderpost beetles as well as the deathwatch beetles. Adults are dark brown or black, sometimes with reddish mouthparts, legs, and antennae. Adults of most species are about $^1/_4$ inch long, but in some species, adults reach $1^1/_2$ to 2 inches in length. Adult beetles have a humpback appearance, so their head is not visible when viewed from above. This characteristic is also seen in deathwatch beetles.

Females bore a tunnel, or egg gallery, into wood or other materials, then deposit their eggs in pores or cracks within the tunnel. Adults of some species bore through soft metal, such as lead and silver, as well as plaster and other nonwood materials, searching for sites to deposit eggs or for protection from weather extremes. This gives rise to the common name "leadcable borer" given to one species because of its habit of boring into the metal covering of suspended telephone wires. In buildings, false powderpost beetles infest floors, furniture, hardwood paneling, and other wood materials.

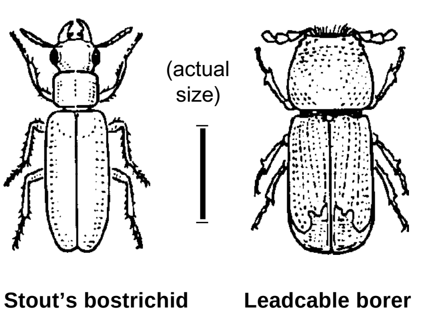

Figure 3. False powderpost beetles.

Table 1. Two Methods for Distinguishing Powderpost, Deathwatch, and False Powderpost Beetles.

	Method	
Beetle	**Ballpoint pen test[1]**	**Frass test[2]**
powderpost beetles (Lyctids)	only tip of pen fits in exit hole	feels like talc
deathwatch beetles (Anobiids)	the tip and part of the angled face fits in exit hole	feels gritty
false powderpost beetles (Bostrichids)	entire point of pen usually fits in exit hole	frass is difficult to dislodge from hole

[1] Insert the tip of a click-type refillable ballpoint pen into the exit hole of the beetle.
[2] To determine the texture of frass, a mixture of feces and food fragments, rub the frass between your fingers.

Two quick diagnostic tests, the ballpoint pen test and the frass test, can help distinguish the three groups of wood-boring beetles. These are described in Table 1.

MANAGEMENT

Wood-boring beetles are difficult to control once an infestation has begun. Prevention is the best management method. Protective measures should be taken at every stage of lumber processing and handling including lumber mills, plywood mills, lumber yards, furniture manufacturing factories, and building construction firms. Sanitation is the most important aspect of prevention. Remove and destroy dead tree limbs around buildings or near any area where wood products are stored. Destroy scrap lumber and other wood products before they become infested. Kiln drying of lumber destroys beetle infestations, although it does not prevent reinfestation. Materials used for construction of buildings and wood furniture should be thoroughly inspected before use to be certain that they do not contain wood-boring beetles. Protect wood from infestation by painting or varnishing to seal pores, cracks, and holes where eggs could be laid.

To keep from accidentally introducing wood borers, inspect furniture and other objects before bringing them into buildings. Fumigate objects that show signs of beetle infestation. When bringing in firewood, only bring in what will be burned that day. Also, inspect the building for signs of wood borer damage. Look for exit holes where adult beetles have emerged. Once galleries have been located, tap out frass to aid in identifying the pest (see Table 1).

Small wooden items (but not those containing fabrics, pelts, or paints) can be heated in an oven at 120° to 140°F for 6 hours or placed in a deep freeze at 0°F for 72 hours. Longer treatments may be required if the wood is thicker than 2 inches. Although room-sized or whole-house treatments for powderpost beetle control are commercially available, there has been no published research on their effectiveness.

Remove and replace infested structural wood whenever possible to eliminate beetles. Destroy infested wood by burning or take it to a landfill area. Where removal is not possible, use liquid insecticides containing materials such as permethrin, cypermethrin, or cyfluthrin that are labeled for the control of these pests. Apply the insecticide only to infested areas, but be sure these are thoroughly soaked. Pesticide formulations containing borate (e.g., Tim-Bor, Bora-Care), which must be applied by a licensed pest control operator, can potentially penetrate the wood and kill beetles within the wood. Depth of penetration is enhanced in moist wood; if moisture is less than 15%, penetration may only be in the top $^{1}/_{4}$ inch. Remove and have infested furniture fumigated. For extensive powderpost and deathwatch beetle infestations within a building, or where inaccessible structural parts of a building are involved, whole-building fumigation is offered by many professional pest control operators. However, there is no published research on the effectiveness of this method for false powderpost beetles, roundheaded wood borers, and flatheaded wood borers. Whenever applying dusts, liquid insecticides, or fumigants, be sure to follow label instructions carefully. Wear the required protective clothing and respiratory equipment.

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HOUSE MOUSE

Integrated Pest Management In and Around the Home

The house mouse (*Mus musculus*) (Fig. 1) is one of the most troublesome and economically important rodents in the United States. House mice thrive under a variety of conditions; they are found in and around homes and commercial structures as well as in open fields and agricultural lands. House mice consume and contaminate food meant for humans, pets, livestock, or other animals. In addition, they cause considerable damage to structures and property, and they can transmit pathogens that cause diseases such as salmonellosis, a form of food poisoning. House mice have not been found to be carriers of the deadly hantavirus.

IDENTIFICATION

House mice are small rodents with relatively large ears and small black eyes. They weigh about 1/2 ounce and usually are light brownish to gray in color. An adult is about 5 1/2 to 7 1/2 inches long, including the 3- to 4-inch tail.

Droppings, fresh gnaw marks, and tracks indicate areas where mice are active. Mouse nests are made from fine shredded paper or other fibrous material, usually in sheltered locations. House mice have a characteristic musky odor that identifies their presence. Mice are active mostly at night, but they can be seen occasionally during daylight hours.

While the house mouse has not been found to be a carrier of hantavirus, other mice have. Most notable are the deer mouse (Fig. 2) and the white-footed mouse, which sometimes invade cabins and outbuildings in California. The house mouse is distinguished from the deer mouse and the white-footed mouse by its overall gray-colored coat. The other two species have a white underside with a distinct line of demarcation between the dark coloration on top and the white underside. In addition, the tail on the house mouse has almost no fur on it whereas the tails of the deer mouse and the white-footed mouse are moderately to well furred and are light underneath and dark on top.

BIOLOGY

Native to Central Asia, the house mouse arrived in North America on ships with settlers from Europe and other points of origin. A very adaptable animal, the house mouse often lives in close association with humans along with Norway rats and roof rats; however, mice are more common and more difficult to control than rats. Although house mice usually prefer to eat cereal grains, they are "nibblers" and will sample many different foods.

Mice have keen senses of taste, hearing, smell, and touch. They are excellent climbers and can run up any rough vertical surface. They will run horizontally along wire cables or ropes and can jump up to 12 inches from the floor onto a flat surface. Mice can squeeze through openings slightly larger than 1/4 inch across.

In a single year, a female may have 5 to 10 litters of about 5 or 6 young. Young are born 19 to 21 days after mating, and they reach reproductive maturity in 6 to 10 weeks. The life span of a mouse is probably 9 to 12 months.

MANAGEMENT

Effective control involves sanitation, exclusion, and population reduction. Sanitation and exclusion are preventive measures. When a mouse infestation already exists, some form of population reduction such as trapping or baiting is almost always necessary.

To devise the best control program for a particular situation, always begin by removing or limiting the mouse's food source and shelter whenever possible. Trapping works well when mice are not numerous, or it can be used as a follow-up measure following a baiting program. When considering a baiting program, decide if the presence of dead mice will cause an odor or sanitation problem. If so, trapping may be the best approach. Removal of mice should be followed by taking steps to exclude them so that the problem does not reoccur.

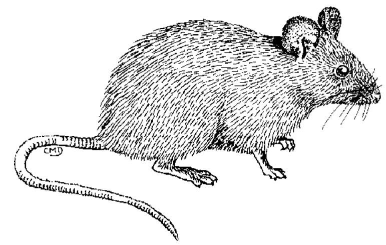

Figure 1. House mouse.

Several types of rodenticides are used in baits: anticoagulant rodenticides, single-dose toxicants, and chronic rodenticides. Because all of these materials are toxic to humans, pets, and wildlife, special precautions must be taken to prevent the poisoning of nontarget animals. Of the rodenticides, the anticoagulant rodenticides are most commonly used around homes because they either require multiple feedings or take several days before they kill the mice, and there is an antidote in case of accidental poisonings.

Figure 2. Deer mouse.

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Sanitation
Because mice can survive in very small areas with limited amounts of food and shelter, their control can be very challenging, especially in and around older structures. Most buildings in which food is stored, handled, or used will support house mice if the mice are not excluded, no matter how good the sanitation. While good sanitation will seldom completely control mice, poor sanitation is sure to attract them and will permit them to thrive in greater numbers. Pay particular attention to eliminating places where mice can find shelter. If they have few places to hide, rest, or build nests and rear their young, they cannot survive in large numbers.

Exclusion
Exclusion is the most successful and permanent form of house mouse control. "Build them out" by eliminating all gaps and openings larger than 1/4 inch, through which mice will enter a structure. Steel wool makes a good temporary plug. Seal cracks in building foundations and around openings for water pipes, vents, and utility cables with metal or concrete. Doors, windows, and screens should fit tightly. It may be necessary to cover the edges of doors and windows with metal to prevent gnawing. Plastic screening, rubber or vinyl, wood, and other gnawable materials are unsuitable for plugging holes used by mice.

Traps
Trapping is an effective method for controlling small numbers of house mice. Although time-consuming, it is the preferred method in homes, garages, and other structures where only a few mice are present. Trapping has several advantages: (1) it does not rely on potentially hazardous rodenticides; (2) it permits the user to view his or her success; and (3) it allows for disposal of trapped mice, thereby eliminating dead mouse odors that may occur when poisoning is done within buildings.

Simple, inexpensive, wood-based snap traps are effective and can be purchased in most hardware and grocery stores. Traps can be baited with a variety of foods; peanut butter is the most popular because it is easy to use and very attractive to mice. Set the triggers lightly so the traps will spring easily.

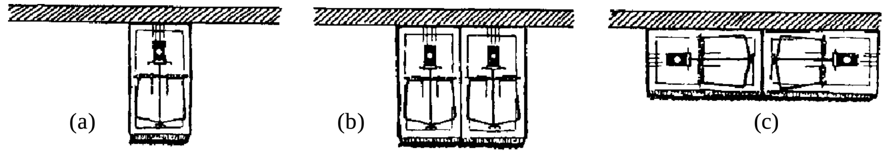

Figure 3. Placement of snap traps: (a) single trap with trigger next to wall; (b) the double set increases your success; (c) double set placed parallel to the wall with triggers to the outside.

Multiple-capture live traps for mice, such as the Victor Tin Cat and the Ketch-All, also are available from hardware stores and pest control suppliers. They can catch several mice at a time without being reset so labor requirements are reduced.

Set traps behind objects, in dark corners, and in places where there is evidence of mouse activity. Place them close to walls so mice will pass directly over the trigger (Fig. 3). Traps can be set on ledges, on top of pallets of stored materials, or in any other locations where mice are active. Use enough traps to make the trapping period short and decisive. Mice seldom venture far from their shelter and food supply, so space traps no more than about 10 feet apart in areas where mice are active.

An alternative to traps are glue boards, which catch and hold mice that are attempting to cross them, in much the same way flypaper catches flies. They are available at many places where other rodent control products are sold. Place glue boards along walls where mice travel. Do not use them where children, pets, or desirable wildlife can contact them. Nontarget animals that become caught on the glue board can be removed in most cases by using vegetable oil as a solvent to loosen the glue. Glue boards lose their effectiveness in dusty areas unless covered. Extreme temperatures also may affect the tackiness of glue boards.

The problem with the traps or glue boards is that you will need to dispose of live mice. The American Veterinary Medical Association states that the only acceptable methods of euthanasia for mice or small rats are decapitation and cervical dislocation. For mice caught on glue boards this means taking a sturdy rod or stick to make a sharp blow to the base of the skull.

Baits
Baits to control rodents are formulated with an attractant (generally food) and a rodenticide (toxin). Most rodenticides used to control mice around the home are already mixed with an attractant in commercially ready-to-use baits. The rodenticides in these baits are either anticoagulants or other rodenticides such as single-dose toxicants and chronic rodenticides.

Anticoagulant Rodenticides. Anticoagulants cause death as a result of internal bleeding, which occurs as the animal's blood loses the ability to clot and capillaries are damaged. The active ingredients are used at very low levels, so the rodent does not avoid the bait because of its taste or the onset of illness. When prepared with good-quality cereals and other bait ingredients, all anticoagulant baits provide good to excellent house mouse control if placed in suitable locations for the mice. The various anticoagulant active ingredients currently registered for use against house mice in California are listed in Table 1.

Because most anticoagulants require that multiple doses be ingested before death occurs, fresh bait must be made available to mice continuously over a period of time. In practice, baits should be offered to mice for at least 2 weeks or as long as feeding occurs. While the newer anticoagulants (such as brodifacoum, bromadiolone, and difethialone) may be capable of causing death after a single feeding, the mice do not die for several days after feeding on the bait. Therefore, the method of setting the bait out is essentially the same as for the older anticoagulant products such as warfarin, pindone, diphacinone, and chlorophacinone. All baits must be used according to the label directions.

Anticoagulants have the same effect on nearly all warm-blooded animals, but the

Table 1. Anticoagulant Rodenticides[1] and the Percent Active Ingredient Usually Found in Food Baits for House Mouse Control.

Common name (example trade names)	Chemical name	% active ingredient used in food bait
brodifacoum (d-Con, Havoc)	3-{3-[4'-bromo(1,1'-biphenyl)-4-yl]-1,2,3,4-tetrahydro-1-naphthalenyl}-4-hydroxy-2H-1-benzopyran-2-one	0.005
bromadiolone (d-Con, Maki)	3-{3-[4'-bromo(1,1'-biphenyl)-4-yl]-3-hydroxy-1-phenylpropyl}-4-hydroxy-2H-1-benzopyran-2-one	0.005
chlorophacinone (RoZol, Eaton AC Formula 90)	2-{(p-chlorophenyl)phenylacetyl}-1,3-indandione	0.005
difethialone (D-Cease, Hombre)	3-(3-(4'bromo(1,1'-biphenyl)-4-yl)-1,2,3,4-tetrahydro-1-napthylenyl'-4-hydroxy-2H-1-benzothiopyran-2-one	0.0025
diphacinone (Ditrac, Ramik)	2-diphenylacetyl-1,3-indandione	0.005
warfarin (d-Con, Rodex)	3-(α-acetonylbenzyl)-4-hydroxycoumarin	0.025

[1] These materials are generally available in retail stores that sell rodent control products.

Table 2. Other Rodenticides[1] and the Percent of Active Ingredient Commonly Used for House Mouse Control.

Common name (example trade names)	Chemical name	% active ingredient used in food bait
bromethalin (Assault, Vengeance)	N-methyl-2,4-dinitro-N-(2,4,6-tribromophenyl)-6-trifluoromethyl) benzenamine	0.01
cholecalciferol (Rampage)	9,10-Seocholesta-5,7,10(19)-trein-3-betaol	0.075
zinc phosphide (Eraze Rodent Pellets)	zinc phosphide	1.0 - 2.0

[1] These materials, with the exception of zinc phosphide, are generally available in retail stores that sell rodent control products.

sensitivity to these toxicants varies among species. If misused, anticoagulant poisoning can cause the death of pets, livestock, or desirable wildlife that may feed on the bait. Additionally, residues of anticoagulants that may be present in the bodies of dead or dying rodents can cause toxic effects to scavengers and predators. In general, however, this "secondary hazard" from anticoagulants is relatively low. Symptoms of anticoagulant poisoning in mammals include lethargy, loss of color in soft tissues such as the lips and gums, and bleeding from the mouth, nose, or intestinal tract. Because anticoagulants are toxic to humans, particular care should be taken to keep rodent baits out of the reach of children. Vitamin K is the antidote for anticoagulant rodenticides, although in cases of severe poisoning, whole blood transfusion is also utilized.

Bait Selection and Placement. Several formulations of anticoagulant baits are available. Grain baits or pelleted forms often are packaged in small plastic, cellophane, or paper packets or are sold in bulk. The "place packs" are designed to keep baits fresh and to make it easy to place baits into burrows, walls, or other locations. Mice will readily gnaw into place packs and feed on baits.

Anticoagulant baits formed into paraffin or wax blocks are useful in damp locations where loose grain baits spoil quickly. Unfortunately, mice may not accept these blocks as readily as they do other baits. Mouse baits containing certain grass seeds are often particularly well accepted by mice, even in the presence of other competing food items.

Proper placement of baits is important for house mouse control. Place baits no more than 10 feet apart in areas where mouse activity is evident. If mice are living in wall spaces, place baits inside the walls.

Other Rodenticides. In addition to the anticoagulant baits, there are currently three other rodenticides available in California for use against the house mouse (see Table 2). Although not anticoagulants, bromethalin and cholecalciferol are used in a manner somewhat similar to the anticoagulant products. These two materials are formulated to serve as chronic rodenticides, so that house mice will have the opportunity to feed on exposed baits one or more times over the period of one to several days. Bait acceptance is generally good when fresh, well-formulated products are used.

The third material, zinc phosphide, differs from bromethalin and cholecalciferol in that it is an acute toxicant that causes death of the mouse within several hours after a lethal dose is ingested. When using zinc phosphide baits, prebaiting (offering mice similar but nontoxic bait before applying the zinc phosphide bait) is recommended in order to increase bait acceptance. If acceptance of prebait is poor, do not apply toxic bait, but change the bait material or its placement. Zinc phosphide bait is not designed to be left available to mice for more than a few days, as continuous exposure is likely to result in the mice learning to avoid the bait, a behavior known as "bait shyness." The advantage of using zinc phosphide bait is its ability to achieve a comparatively quick reduction of a mouse population. Because bait shyness can occur with zinc phosphide baits, these products should not be used more frequently than once or twice per year at any given location.

When using any rodenticide, carefully follow label instructions and understand all precautions. Remove and properly dispose of all uneaten bait at the end of a control program. Also, it is wise to collect and properly dispose of any dead rodents found during the course of rodenticide application. You can pick them up, using a sturdy plastic bag inverted on your hand, and seal them in the bag for disposal with household garbage, or bury them in a location where they will not be easily dug up by pets or scavengers.

Bait Stations. Bait stations are very useful when applying the chronic and single-dose toxicant rodenticide baits. They protect rodenticides from weather and provide a safeguard to people, pets, and other animals. Bait stations should have at least two openings about 1 inch in diameter and should be large enough to accommodate several mice at one time. Place bait boxes next to walls (with the openings close to the wall) or in other places where mice are active. It is best to place bait stations between the source of shelter and the food supplies that the mice are using. Clearly label all bait boxes “Caution — Mouse Bait” as a safety precaution. Some rodenticide labels or situations may require use of approved tamper-resistant bait stations. If so, be sure to secure these stations to buildings by nailing or gluing them to walls or floors in a way that will not permit a person or animal to knock them over or shake the bait out.

Where it is impossible to exclude rodents from structures, establish permanent bait stations in and around the perimeters of buildings. Place fresh bait in these stations to control invading mice before mouse populations become established. Check bait stations regularly and replace bait if it gets old and moldy, because mice will not eat moldy bait.

Electronic Devices

Although mice are easily frightened by strange or unfamiliar noises, they quickly become accustomed to regularly repeated sounds. Ultrasonic sounds, those above the range of human hearing, have very limited use in rodent control because they are directional and do not penetrate behind objects. They also lose their intensity quickly with distance. There is little evidence that electronic, sound, magnetic, or vibration devices of any kind will drive established mice or rats from buildings or provide adequate control. Despite their lack of effectiveness, such devices continue to be sold through magazine advertisements and at some retail outlets.

Predators

Some dogs and cats will catch and kill mice and rats. There are few situations, however, in which they will sufficiently control rodent populations. Around most structures, mice can find many places to hide and rear their young out of the reach of such predators. Cats probably cannot eliminate existing mouse populations, but in some situations they may be able to prevent reinfestation once mice have been controlled. In urban and suburban areas, it is not uncommon to find rodents living in close association with cats and dogs, relying on cat and dog food for nourishment. Mice frequently live beneath doghouses and soon learn they can feed on dog food when the dog is absent or asleep.

SUGGESTED READING:

Berry, R. J., ed. 1981. Biology of the house mouse. *Symp. Zool. Soc.* London, No. 47.

Corrigan, R. M. 1997. Rats and mice. In *Handbook of Pest Control,* 8th Ed. Cleveland: Mallis Handbook & Technical Training Co. pp. 11-105.

Hygnstrom, S. E., and D. R. Virchow. 1992. *Controlling House Mice.* Lincoln: Univ. Neb. Coop. Ext. NebGuide G92-1105-A.

Marsh, R. E., and W. E. Howard. 1981. *The House Mouse: Its Biology and Control.* Oakland: Div. Agric. Sci. Univ. Calif. Leaflet 2945 (rev.)

Meehan, A. P. 1984. *Rats and Mice: Their Biology and Control.* E. Grinstead, U.K.: Rentokil Ltd.

Salmon, T. P., and R. E. Lickliter. 1984. *Wildlife Pest Control around Gardens and Homes.* Oakland: Univ. Calif. Div. Agric. Nat. Res. Publication 21385.

Timm, R.M. 1994. House mice. In *Prevention and Control of Wildlife Damage.* Vol. 1. S. E. Hygnstrom, R. M. Timm, and G. E. Larson, eds. Lincoln: Univ. Neb. Coop. Ext. pp. B.31-B.46.

For more information contact the University of California Cooperative Extension or agricultural commissionerÕs office in your county. See your phone book for addresses and phone numbers.

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WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

IPM for Rats in Schools

Adapted from Daar et al., 1997

Rats damage food, clothing, documents, and structures through gnawing, urination, defecation, and nesting activities. The damage to food from contamination is probably ten times greater than the damage by direct feeding. Feces and urine raise the humidity of enclosed spaces, promote wood deterioration, and provide a medium for proliferation of microorganisms (Frantz, 1988). Rats cause fires by chewing through the insulation on electrical wires, and they are involved in spreading human pathogens, such as bubonic plague.

The best approach to rat problems combines careful inspection, regular monitoring, sanitation, garbage management, rat proofing, trapping, and, if necessary, baiting with toxicants. Unless the conditions that attracted rats in the first place are changed, new rats often move into the habitat vacated by the dead ones, and the cycle will continue.

Although setting out poison baits is the common response to rat problems, this tactic has been overused, and some rats are no longer affected by the poison. Even when baits remain effective, poisoned rats frequently die in inaccessible places where their decomposing bodies create unpleasant odors and provide food for pest insects such as flesh flies and carpet beetles. Moreover, on school grounds, there is always a risk that children or pet animals will inadvertently encounter the bait.

Biology

It is important to identify which rat species is present. **Table 7.2-1** shows the differences between the Norway rat and the roof rat. After trapping a rat, you can use information from this table to identify it.

The two most common pest rat species in California, both introduced from Europe, are the Norway rat, Rattus norvegicus, and the roof rat, Rattus rattus. Rats can reproduce year round in subtropical climates. In cooler climates, populations peak on spring and autumn. Gestation period is 20 to 25 days, with the pups weaned at around 30 days. The average litter size is 5 to 12, with up to nine litters per year, depending on food availability. Sexual maturity for the Norway rat is 75 to 90 days and 68 to 90 days for the roof rat. The life span of rats in the wild is less than one year.

The Norway rat, considered the most important pest rat in California, is also known as the brown, wharf, house, gray, or sewer rat. It occurs in every state. The roof rat, also known as the ship, black, or Alexandrine rat, occurs mainly along the coastal U.S., including the Pacific coast states, the Gulf states, and the southern and Atlantic states.

Characteristics of rats that can have an impact on management include the following:

- They will feed on a wide variety of materials (see **Table 7.2-2** for more specific information).
- Rats usually search for food between dusk and dawn, but when hungry or living under crowded conditions, may be seen in the daylight.
- They require water daily, unless food items are succulent.

Table 7.2-1: Difference Between the Norway Rat and the Roof Rat

	Norway Rat	Roof Rat
Scientific name	Rattus norvegicus	Rattus rattus
Other common names	brown, wharf or sewer rat	black, ship or house rat
Adult weight	3 to 21 ounces	3 to 12 ounces
Snout	blunt	pointed
Ears	small & thick with short hairs	large & thin without hair
Tail coloration	dark above, pale underneath	all dark
Fur	brown with black; shaggy	light brown, gray to black; smooth
Droppings	capsule-shaped, pointed	pointed & curved
Food requirement	about 1 ounce/day	1 ounce or less/day
Water source	free water*	free water*
Climbing ability	can climb	active climber
Nest locations	mainly in burrows	walls, attics, trees
Swimming ability	excellent	can swim

*Water present by itself and not simply a constituent of the food eaten by the rat. Free water unnecessary when feeding on succulent foods, but needed if diet is dry and/or high in protein.

Sources: Frantz & Davis, 1991; Olkowski et al., 1991

Table 7.2-2: Nesting and Eating Habits of the Norway Rat and the Roof Rat

	Norway Rat	Roof Rat
Nesting Sites Outdoors	In the ground, in burrows that are less than 18 inches deep and less than 3 feet long; burrow openings are 2 to 4 inches in diamter; burrow system can be quite complex and interconnected; in unused sewers or storm drains.	Usually above ground: in trees, especially untrimmed palm trees; in dense, overgrown vegetation, especially Algerian ivy (Hedera canariensis); and in piles of wood and debris in the ground if there are few suitable above-ground sites and there are no Norway rats nesting in the area in unused sewers or storm drains.
Nesting Sites Indoors	Usually in the lower floors of the building; in wall voids and crawl spaces; in storage rooms under pallets or equipment; behind seldom-used stored materials at the corners and backs of rooms; in any cluttered area that is little used.	Usually in the upper part of the building; in the attic; in ceiling and attic voids; can also nest in the lower floors of a building.
Eating Habits	More likely to eat garbage than roof rats. prefer foods that are high in protein, such as fish, meat, nuts, grains, pet food insects.	Prefer fresh plant material, such as nuts and seeds, fruit and vegetables, and tree bark. Sometimes eat garbage and meat.

Sources: Meehan, 1984 and Ingles, 1965

- Rats can travel several hundred feet from their nests in search of food, depending on the relationship of food to nesting resources.
- They prefer traveling along edges, e.g., the edge of the floor next to the wall, along the outside or inside of a foundation. They also travel along pipes, rafters, and for roof rats, overhead utility lines.
- They are wary of crossing open spaces that provide no cover.
- Rats have poor visual acuity, but are quite sensitive to patterns and contrasts.
- They have acute senses of smell, taste, touch, and hearing; navigate using their whiskers and guard hairs.
- They tend to be extremely wary (though temporarily) of new objects in their environment.

In general, Norway rats build their nests in underground burrows or in ground-level areas in buildings while roof rats prefer living in elevated areas. Table 7.2-2 provides more specific information.

Rats have amazing physical abilities. Understanding what they can and cannot do is very important when planning ways to prevent rat problems or to reduce the number of rats present.

Detection and Monitoring

Management of rats always begins with a systematic survey and evaluation of the site. Make a thorough inspection to find as many of the active infestations as possible. At the same time note all possible harborage sites, sources of food and water, and holes that provide access to the building. **Box 7.2-1** details the signs of rat infestation, and **Boxes 7.2-2** and **7.2-3** summarize the areas to inspect inside and outdoors. Make detailed notes about problem areas on a map of the building. Do not neglect to inspect any outbuildings on the property.

Effective monitoring involves each of the following steps. Make a site plan of the school with separate drawings of each floor so you can accurately record information. Lightly dust smooth surfaces near suspected harborage, runs, or entry points with unscented talcum powder or powdered chalk to gain further information. Footprints and draglines (made by tails) across powdered surfaces indicate rat traffic. The powder can also be dusted onto a heavy, smooth material such as a piece of floor tile that can be moved around. Holding a flashlight at a low angle helps to illuminate tracks on dusty surfaces.

Inspect at night with a strong flashlight. Look for movement and listen for squeaking, scrambling, and gnawing sounds. Vacuum up fecal pellets and gnawed wood shavings and remove any nests. Reinspect for new rat signs in a day or two.

Place a piece of gray paper or cardboard in dark or hard-to-reach areas and inspect them later for fecal pellets. Temporarily close suspected rat burrows or openings with soil, crumpled paper, aluminum foil, or sawdust. Inspect 24 hours later to see if the holes have been opened or the paper chewed or moved.

Monitoring Blocks/Monitoring Stations

Non-toxic, food attractant blocks are commercially available for monitoring rats. You can also use bait stations filled with non-toxic baits such as rabbit food or grains. These monitoring blocks or stations can be placed anywhere indoors or out to locate or monitor a rat population simply by noting whether animals have fed on the bait. Monitoring blocks or stations can also help you gauge the effectiveness of your treatment efforts. The blocks or bait stations should be wired, staked, or glued down with caulk so they cannot be dragged away. Mark the blocks or stations clearly with a tag alerting people that a

Box 7.2-1

Live or Dead Rats

Seeing live rats is the most obvious and certain sign of their presence. Seeing live rats in the daytime usually means there is a heavy infestation, that their harborage has been disturbed, or that new rats are moving into the area and haven't found any harborage yet. A freshly dead rat is a sign of infestation, but this is not necessarily true with an old, dried body, which may merely indicate a previous infestation.

Droppings

- The largest number of droppings will be in feeding areas and near harborage.
- Rat droppings may be as large as 3/4 inch long and 1/4 inch in diameter.
- Fresh droppings are moist, soft, black or nearly black, and they glisten or look wet. After a few days to a week, the droppings dry, become hard, and appear dull rather than shiny. In warm, dry atmospheres, the droppings can lose their shine after only a few hours. After a few weeks, rat droppings become gray, dusty and crumbly.
- If very old droppings are moistened, they may look like new ones, but they will still be crumbly instead of soft.
- Sometimes lizard or bat droppings can be confused with rats droppings, but both lizard and bat droppings contain many insect fragments that can easily be seen when the droppings are crushed.
- To monitor for current rat activity, remove the droppings so that fresh droppings are apparent during future inspections.

Damage to Goods and Structures

- Rats gnaw to get at food in packaging or containers and to obtain nesting material.
- When rats gnaw, their front teeth leave two parallel marks, about _inch across.
- Gnaw marks on doors or ledges, in corners, in wall material, or on stored materials as well as bits of gnawed wood, paper, cloth or packaging, are good indications of rat presence.
- Rats can gnaw through rusty sheet metal and sheet aluminum.

Grease Marks or Rub Marks

These marks on beams, rafters, walls, pipes, and other fixtures are the result of oil and dirt rubbing off rats' fur along frequently traveled routes.

Runs or Burrows

These may be found outside along foundations, walls, or fences or under bushes or debris. Runs will look like tiny paths and burrows are open holes.

Tracks

Footprints and long, thin marks indicating a tail being dragged or rested can easily be seen on dusty surfaces, in mud, or in snow.

Noises

As rats gnaw, claw, fight, and scramble around inside walls they make noises. These are particularly audible at night when they are most active. A stethoscope may be used to pinpoint the activity. Note that squirrels and other animals can make similar noises, so you should confirm rat presence with other signs.

Urine

Rat urine will fluoresce blue-white under ultraviolet light, but many other substances also fluoresce, so recognizing rat urine takes skill.

Adapted from Meehan, 1984

non-toxic, rat monitoring program is underway.

Number each block or station and note its location on your map. In two to seven days, check for signs of rat feeding and record the amount on a monitoring form.

The following are some of the best locations to place monitoring blocks:

- Food storage areas.
- Kitchens-in closets and food storage areas.
- Locker rooms, break rooms, and teacher's lounges.
- Attics.
- Basements.
- Under and behind cabinets, appliances, computers, and electrical boxes.
- In storage sheds, especially any containing grass seed or bird seed.
- Outdoors in dense vegetation and along buildings and fences.

Management Options

Initially, concentrate control efforts in the high-risk/high-priority areas, such as the kitchen, the cafeteria, locker rooms, and perhaps various storage rooms. Your inspection will reveal the precise areas you must concentrate on in your own school. After you have improved sanitation in these areas, worked on rat exclusion, and trapped most of the offending animals, move on to the other areas you noted in your inspection. You need not tackle the entire school at once.

Habitat Modification and Sanitation

It is very important to change the physical environment that is supporting rats. As mentioned before, if rats are killed but habitat and food are still available, it is very likely that new rats will move in to replace the dead ones.

Reducing Food Availability

Store foods such as grains, pet foods or snacks in metal, glass, or heavy plastic containers with tight-fitting lids. Food stored in classrooms or teachers' lounges should be in tightly closed containers. Do not leave food out overnight. Do not allow students to store food in their lockers overnight unless it is in rat-proof containers. Explaining to them why this is important will help with compliance.

Store fresh fruits and vegetables in refrigerators or in open-air coolers that are screened with 1/4 inch, heavy wire mesh. Store bags of grass seed, dry pet food, and other similar items in rat-proof containers, or at the very least, inspect them frequently for any signs of chewing. Promptly clean up any spilled birdseed around feeders.

Limiting Areas for Eating

If you expect to contain and limit pest problems (cockroaches and ants as well as rats), it is very important to designate appropriate areas for eating and to enforce these rules. The fewer designated areas, the easier it will be to limit the pests.

Managing Garbage Properly

In most areas, garbage is the main source of food for rats. An electric garbage disposal unit in the sink can make rat problems worse by providing them with food in the sewer system. Proper disposal of organic garbage (food waste, garden waste, pet waste) is essential.

All food waste from the kitchen, cafeteria, and other areas should be separated from other garbage, drained so it will be as dry as possible, and then stored in sealed plastic bags. These bags must be

Box 7.2-2

How to Conduct a Rat Inspection Inside

1. Begin in the basement or substructure. Remember that you are trying to find as many areas as you can that might provide harborage, food, water, or access to the building.
2. Make detailed notes on your schematic of the building.
3. Try to locate all entry points and nesting areas. "Starter holes" for rats to enlarge can be openings as small as 1/4-inch in diameter in walls, around pipe entries, sewer outlets, under doors, etc. Unscreened sewer outlets and even toilets can give rats access to buildings. Nests are often composed of things like shredded paper, pieces of plastic, and bits of fabric gathered together into a 8 to 12 inch diameter mass. If you find clothing or paper that looks torn or shredded but doesn't look like a nest, you will most likely find the nest nearby.
4. Look for water leaks and rooms where water condenses on the walls.
5. Always be on the lookout for piles of trash, clutter, or other debris.
6. Note where the custodians, teachers, and students take their breaks or eat lunch. These areas can present a sanitation problem.
7. Rats like to follow edges; inspect these areas for feces, rub marks, urine, or other indications of activity.
8. Move to the main floors of the building and inspect locker rooms, home economics rooms, art rooms, childcare areas, lower-grade areas, cafeteria, kitchen, and teachers' lounge. Even science rooms can have food for rats.
9. Continue into the attic to look for holes, nests, feces, and rub marks.

Adapted from Harmon, 1995

Box 7.2-3

How to Conduct a Rat Inspection Outside

1. Try to identify as many of the areas as possible that provide rats harborage, food, water, and access to the building.
2. Make detailed notes on your map of the exterior of the building and the school grounds.
3. Take note of how garbage is dealt with, what condition dumpsters and garbage cans are in, and whether rats have easy access to garbage.
4. Check doorways for gaps or holes and note windows without screens or glass.
5. Look for other openings in the structure-holes, vents without screens, holes around plumbing, and electrical wire entry points.
6. Note any power lines running into the upper portions of buildings and any trees which are brushing up against the structure; these give rats access to the roof.
7. Note any bird or bat problems because rats may not be far behind. Rats will feed on bird eggs, chicks, and young bats.
8. What kind of vegetation is growing near the building? Does it give rats cover for runways or nesting sites? Are there any fruit- or nut-bearing trees?
9. Inspect all planters, wood waste piles, portable storage containers, and outbuildings. Are there signs of rat infestation in or around any of these areas?
10. Take into account any field or lot which may be next door, as well as any supermarket or fast food establishment that may attract rats. Rats that start to invade the school may be an overflow from adjoining properties. If a vacant building next door to a school is going to be renovated or an empty field or lot prepared for construction, the rat population will be displaced to the surrounding areas.
11. Check for irrigation leaks and any standing water such as irrigation or drainage ditches, stagnant pools, ornamental ponds, and fountains.
12. On the roof, check air conditioning units that might provide water and harborage for rats.

Adapted from Harmon, 1995

placed in rat-proof containers at the end of each day because plastic bags are not rat-proof.

In food preparation areas, thoroughly rinse all cans, bottles, and plastic containers before recycling or discarding. Make sure garbage can and outdoor trash container (e.g., Dumpsters(tm)) lids seal tightly when closed, and remain closed when not in use, especially at night. Repair or replace garbage cans with holes or with lids that do not close tightly. Use stretchy fasteners over garbage can lids, if necessary.

Clean garbage cans and outdoor trash containers frequently to prevent the build-up of food waste. Dirty garbage cans not only attract pests, but also repel people who want to use the garbage cans so that trash ends up outside the can. Use a high-pressure stream of water or a brush and soapy water, if necessary. If possible, outdoor trash containers should be fitted with drains so dirty water can be drained. The plug should be snugly in place, except when hosing out the outdoor trash container; otherwise, rats can enter the container and it becomes a huge feeding station. Another option is to require the refuse company to clean the container or replace it with a clean one more frequently.

Do not store extra garbage in cardboard, plastic, or paper outside the garbage cans because they can be torn open by rats, dogs, raccoons, or other animals. Inspect outdoor trash receptacles at the end of the day, and pick up any wastes lying on the ground. Garbage cans on the school grounds should have removable, domed tops with vertical, spring-loaded swinging doors. Line these cans with plastic bags that can be tightly sealed and emptied into rat-proof garbage containers every evening. Inform students, teachers, and staff of the importance of placing garbage inside the proper containers.

Pick up cat and dog feces daily (rats will feed on these). Shovel, rake, or sweep up fallen fruit, nuts, and similar foods that may be feeding rats in the schoolyard. Dispose of in rat-proof garbage containers. Sometimes it may be necessary to strip trees of their fruits or nuts to get a rat problem under control. Store excess garden produce away from rats or dispose of it in rat-proof garbage containers.

Debris and Clutter

Clean up and organize storage rooms to eliminate as much clutter as possible. It's harder to detect rat presence in such rooms and the clutter is attractive harborage. Outside, remove debris heaps, wood piles, or construction debris.

Water

Freestanding water in stagnant pools, ditches, ornamental pools, or fountains can provide rats with their daily ration of water. Drain or eliminate these sources where possible. Fountains and ornamental pools will pose a problem, but during severe rat infestations, they may need to be temporarily drained.

Fix all leaking pipes, faucets, or broken irrigation systems. Eliminate condensation in places like boiler rooms.

Removing Vegetation

Trim trees, vines, bushes, grass, and weeds at least 12 to 18 inches from all buildings to decrease cover for rat runways and prevent hidden access to buildings. Break up dense plantings with pathways, stretches of lawn, or very low groundcover. Rats don't like to move across areas where they can be easily seen. Avoid large plantings of a single groundcover that could allow rats to run for long distances without being seen. Thin out dense bushes to reduce rat habitat.

Avoid planting date palms or Algerian ivy (Hedera canariensis) on the school grounds because rats can live in and feed on these plants.

Exclusion

Exclusion must be the basis of any reliable management program. Rat proofing will take time and should begin simultaneously with trapping and/or poison baiting. The following procedures are recommended:

Large Openings in the Exterior of the Structure

Seal openings larger than three inches in diameter with 1/4-inch hardware cloth, 19-gauge or thicker sheet metal, plaster, or mortar. Make supports or frames for the screen and make sure they are secured solidly to the building. If maintenance staff needs access to the opening, install a lockable door with a heavy-duty spring hinge that will automatically close the door if someone forgets.

Look for openings in the building not only in the first three feet above the ground, but also at the roof line, in the eaves, and in attic and roof vents. Make sure all vents are screened with 1/4-inch hardware cloth and that existing screen is not ripped. Cover vent pipes with a square of 1/4-inch hardware cloth bent around the pipe and secured with a wire.

Small Openings in the Structure, Inside or Out

Depending on the material in which you find these openings, holes as small as 3/16 inch in diameter should be sealed. These holes are very important and are often difficult to find. If the holes are in materials that rats can gnaw, they can enlarge these holes until they can eventually squeeze through them. Seal small holes with steel or copper wool (copper will not rust) or with caulk.

Check for gaps around exterior doors and seal with weather stripping. Metal kick plates can be used to prevent rat entry. Use raised metal doorsills when necessary. Some doors have vents or louvers in them as part of the ventilation system. It may be necessary to screen these. Sometimes pipes have been installed through the vents or louvers; make sure to seal any gaps around the pipes. Check areas where pipes and wiring enter buildings and close any gaps with caulk or with steel or copper wool.

Air Conditioners

These units can provide rats with water, harborage, and access to the structure. Make sure each unit is well sealed, especially those on the roof.

Sewer Pipes

Repair broken sewer pipes. Rats can dig into broken sewer lines and swim up the trap in a toilet to get into a building. Toilet drains can be rat-proofed by feeding the pipe from the toilet bowl into a pipe section of larger diameter (Frantz and Davis, 1991).

Drains

Cap the drains in basement floors so rats cannot enter through them. Install a brass drain cover or a perforated metal cap held in place by a hinge so it can be opened for cleaning. Make sure the unhinged type of cover is threaded so it screws in place; otherwise, a rat can push it open. Place 1/4-inch galvanized hardware cloth under existing drain covers with holes larger than 1/2 inch.

Installing Barriers

Make rat-proof barriers to separate landscaping from the foundations of buildings by digging a small trench 8 to 12 inches wide, 8 inches deep, and as long as the building. Fill this with pea gravel.

Rats dislike burrowing in loose gravel so will be discouraged from trying to penetrate the foundation.

Barriers should be placed between and within walls to prevent rat travel. An open space between floor joists gives rats free access to wall voids. Wood 2_ x 4_ stops are sometimes used on upper floors, but an incombustible material should be employed on lower floors. In old buildings, galvanized sheet metal can be cut to fit and nailed between studs, joists, floor, and sill. In new construction, incombustible stops of a good grade of cement are recommended.

Pallets containing stored food and paper supplies can be rat-proofed by elevating the pallet on 12-inch cinder blocks, then covering the pallet with a layer of sheet metal so that the edges of the sheet metal extend four to six inches beyond the edges of the pallet. The edges should then be bent down toward the floor at a 45° angle.

Population Reduction: Trapping

Many schools have concerns about the ethical implications of killing rats slowly by trapping. Snap traps are probably the most humane in that regard because they kill the animals swiftly. These concerns for the animals can be turned into motivation for habitat modification and other strategies that exclude rats and eliminate their food supply, thus reducing the numbers that have to be directly killed. Be sure to inspect the traps daily to remove and humanely kill any rats that have been caught.

Killing trapped rats

The American Veterinary Medical Association states that the only acceptable methods of euthanasia for small rats are decapitation and cervical dislocation. For small rats caught on glue boards this means taking a sturdy rod or stick to make a sharp blow to the base of the skull. Drowning is considered inhumane so is not regarded as euthanasia.

Tips for a successful trapping program

- Set traps in the correct locations, bait properly, and inspect frequently-sometimes this will mean daily.
- Use the map of the building and/or grounds to record the precise location of each trap and the date it was set. This record keeping is the key to preventing lost and forgotten traps. If dead and decomposing rats are left in the traps, the results can be very unpleasant.
- When handling traps, always wear gloves for protection from diseases.
- Rats will avoid traps for a few hours to several days after initial placement. "Pre-baiting" traps for rats (see below under Baits) can improve catches.
- If catches are poor, try moving the traps to new locations.
- When most of the rats have been trapped, it can be hard to catch the last few because they may have become trap-shy and will avoid the traps. In such cases, the traps can be removed for a week, and then set in new locations using the pre-baiting method described below. You can also leave out food in shallow pans until the rats readily eat it, and then camouflage the trap by burying it under the food in the pan.

Trap choices

Rat traps fall into three general categories: snap traps, live traps, and glue boards. The information below will help you decide where to best use each of the traps.

Snap Traps. These traps are widely available and can be made more effective by expanding the trigger so that it can be tripped by a rat simply running over the trap. Do not place them where human toes might accidentally get caught, unless the traps are protected inside a bait station (see below). These traps work well in dusty places, but do not use a snap trap in an area with standing water or high humidity because the mechanism will rust and the trap will be useless.

Live Capture Traps. Live traps are available for rats, but the rats must be killed once they are trapped.

Glue Boards. These traps are covered with a sticky material that will catch small rats. Glue boards provide the advantage of catching and retaining rat hairs, droppings, and ectoparasites coming from the trapped animal. Glue board traps should be inspected daily in order to prevent unnecessary suffering by the trapped animals.

If glue boards are used in areas where they might fall and stick to something, secure the traps with a nail or wire. Boards should always be secured when you are trapping rats so that if the rats are only partially caught they cannot drag the traps away. Baiting glue boards is not necessary but bait will improve the chances of success.

Trap Placement

Check the monitoring map to locate active rat holes, and set traps along walls or other runways leading to the holes. Other good trap locations include areas near droppings, gnawing marks, or other signs of rat damage; under and behind objects likely to harbor rats in dark corners; and along rafters or other protected areas where rats are likely to travel. Move objects around to funnel rats into the traps.

Set traps at right angles to the wall, with the trigger facing the wall. Place traps flush with the wall so that rats traveling along the edge of the wall will encounter the traps. Two traps, side by side with their triggers facing the wall, can increase the chances of success. Alternatively, the two traps can be placed parallel to the wall, back to back with their triggers facing away from each other. Three traps in a row will make it difficult for a rat to jump over the traps without being caught.

Traps can also be nailed to a wall or rafter or wired to a pipe. Make sure the trigger side of the trap is projecting into the rats' runway. When trapping rats with snap traps, it may be useful to secure the trap so that if a rat is only partially caught, it cannot drag the trap away to an inaccessible area.

A trap can be camouflaged by sinking it just below ground level on dirt surfaces. This is done by positioning the trap and then completely covering it with a fine layer of sand or sawdust. Traps can also be set in shallow pans filled with sawdust, grain, or meal. It may be necessary to place a small piece of cloth over the trigger to keep it from jamming.

Baiting the Traps

Baits for Norway rats include pieces of hot dog, bacon, liver, peanut butter, or nutmeats. Suggested baits for roof rats include nuts, dried fruits, or fresh fruits such as bananas or apples. You can also try other baits such as candy, marshmallows, raisins, or peanut butter mixed with rolled oats or bacon grease. Many of these baits don't last long because they dry up or become rancid. If rats are feeding on other foods, try them as baits also.

To catch rats, you will probably have to "pre-bait" the traps. Place the traps out with bait but do not set the traps. Check them daily to see if the bait has been taken, and move them to a new location if the bait remains undisturbed. Once you see signs of feeding on the bait, refill the bait and set the traps.

Alternatively, pre-bait the traps with a large piece of peanut butter, hot dog, liver, or fruit. When you are ready to set the traps, remove the large piece of bait and smear a small bit on the underside of the trigger. The animals will have become used to taking the bait from the trigger and will now try to manipulate the trigger to find the bait they know should be there. Cereal (like oatmeal) can be sprinkled around the traps to make them more attractive. Remember that you will probably have to experiment to find the bait that works best in your situation.

Number of Traps to Use

It is difficult to give a formula for the number of traps to use because the appropriate number will depend on the situation; however, it is better to err on the side of too many traps than too few. Place traps where you see activity and try using traps every two to three feet along a wall. You may need three to six traps around each hole or burrow opening.

Concentrate the traps in one area at a time. When you have finished trapping in that area, move the traps to your next target.

Biological Controls

Some institutions maintain cats for protection against rats. Cats can “prune” a rat population but seldom eliminate it. They can be a deterrent to new rat immigration, although it is entirely possible to have alert cats and still have rats present. Owls and snakes are rat predators, so when considering the use of chemical control techniques, remember that depending on the toxicant used, these predators can be killed by consuming poisoned rats.

Chemical Controls

If non-chemical methods alone prove insufficient to solve the problem, then integrating a rodenticide into your management program may be warranted. Consult your local county office of the University of California Cooperative Extension for advice about the use of particular chemicals. They specialize in helping people with questions about pest problems. You can find your county office in the phone book or online at http://danr.ucop.edu/regional.htm. You can search for specific registered products in the DPR product and label database at http://www.cdpr.ca.gov/

Rodenticides must be used in accordance with their U.S. EPA-approved label directions. Applicators of restricted use materials must be certified to apply pesticides. Pesticide applicators should always wear protective gear during applications. All labels and Material Safety Data Sheets (MSDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials when buildings are occupied, and never apply them where they might wash into the sanitary sewer or into outside storm drains.

A pesticide product deployed in the form of a self-contained bait or trap is exempt from the posting and notification requirements of the Healthy Schools Act. Baits and bait stations will be avoided by the rats for a few hours to several days after initial placement. Even after this period, rats will be very cautious about approaching them. If a rat nibbles on a bit of poison bait that later makes it sick without killing it, the rat will avoid similar baits in the future, and, if female, may teach her young to do the same.

When to Use a Poison-Baiting Program

It is appropriate to use poison-baits when both trapping and physical changes to the building and to food and waste storage have been clearly documented to be ineffective. In emergency situations when there are very high numbers of rats or when rat fleas have been identified as transmitting bubonic plague, it may be appropriate to use poison baits, but trapping and habitat modification must also be used at the same time.

Be aware that overuse of some rodenticides has produced rat populations resistant to the poisons. Rodenticides should be used only if necessary. This approach preserves their effectiveness when they are needed to handle emergencies.

Instituting a Poison Baiting Program

Before beginning a baiting program, use monitoring blocks or stations (see the discussion under "Detection and Monitoring", above) to determine the locations where rats are most likely to accept poison bait.

Points to remember when instituting a baiting program:

- Bait stations must always be secured in place and clearly labeled "RAT BAIT-POISON-DO NOT TOUCH."
- Set out bait stations only where rats are most active and have previously gnawed on monitoring blocks.
- Place bait stations along walls and between shelter and the source of food. In the case of roof rats, bait stations should be placed above the ground in areas such as attics, roofs, or trees.
- For rats, bait stations should be placed 15 to 30 feet apart.
- Mark the location of each bait station on your building map.
- Check each bait station daily to make sure there is enough bait (this is extremely important), the bait is in good condition (not moldy or rancid), and the bait station is not being tampered with.
- Leave bait stations in place for the number of days recommended on the label. It may take four or more days for the rats to try the bait.
- Multi-dose anticoagulants take from four to nine days to kill rats if the bait is the only food source.
- Rats have an excellent sense of taste, enabling them to detect extremely small amounts of rat poison very quickly. For this reason, poisoned baits must be more attractive to rats than the other foods that are available to them in the area.
- Remove and securely store all bait stations when the baiting program is over.

Bibliography

Bio-Integral Resource Center (BIRC). 1996. 1997 Directory of Least Toxic Pest Control Products. IPM Practitioner 18(11/12):1-39.

Baker, R.O., G.R. Bodman, and R.M. Timm. 1994. Rodent-Proof Construction and Exclusion Methods. In: Prevention and Control of Wildlife Damage, pp. B137-B150. University of Nebraska, Lincoln.

Caslick, J.W. and D.J. Decker. 1980. Rat and Mouse Control. Cornell Cooperative Extension, Ithaca, NY, Bulletin 163.

Centers for Disease Control and Prevention. 1993. Hantavirus Infection-Southwestern United States. Interim recommendations for risk reduction. Morbidity and Mortality Weekly Report 42(No. R-11):1-20.

Corrigan, R.M. 1994. Managing field mice. Pest Management 13(7):8-12.

Daar, S., Drlik, T., Olkowski, H., and Olkowski, W. 1997. IPM for Schools: a How-To Manual. Bio-Integral Resource Center, Berkeley, CA. 215 pp.

Dodds, W.J., S.C. Frantz, and K. Story. 1986. The Professional's Guide to Managing Poisoning by Anticoagulant Rodenticides. Chempa Products Div., Lipha Chemicals, Inc., New York. 10 pp.

Ebeling, W. 1975. Urban Entomology. University of California, Los Angeles. 695 pp.

Fehrenbach, P. 1994. Are PCO's at risk? Pest Control Technology 22(8):32-34,108.

Frantz, S.C. 1979. Rodent Control-A Case for Integrated Pest Management (IPM). U.S. Public Health Service, Center for Disease Control, Preventive Health Services Conference, Ellenville, NY. May 7-11, 1979. 29 pp.

Frantz, S.C. 1980. Integrated Pest Management: Philosophy and Basic Guidelines. National Association of Housing and Redevelopment Officials, Albany, NY. Sept. 3 -4, 1980. 20 pp.

Frantz, S.C. 1988. Architecture and commensal vertebrate pest management. In: Architectural Design and Indoor Microbial Pollution, R.B. Kundsin, ed., Oxford University Press, New York, NY.

Frantz, S.C. and D.E. Davis. 1991. Bionomics and integrated pest management of commensal rodents, pp. 243-313. In: Gorman, Ecology and Management of Food-Industry Pests. Association of Official Analytical Chemists, Arlington, VA.

Frantz, S.C. and C.M. Padula. 1990. Recent developments in anticoagulant rodenticide resistance studies: surveillance and application in the United States. In Proceedings of the 9th Vertebrate Pest Conference. J.P. Clark, ed. University of California Press, Davis, CA. pp. 80-88.

Goldstein, M.M. 1995. Teaching old pro's new tricks: utilizing existent rodent IPM tools in new ways can result in greater rodent catch and time savings. Pest Control Technology 23(8):48,50,52.

Gorman, J.R., ed. Ecology and Management of Food-Industry Pests. FDA Tech. Bulletin 4. Association of Official Analytical Chemists, Arlington, VA. 595 pp.

Gunther, R., et al. 1988, Toxicity of vitamin D3 rodenticides to dogs. Journal of the American Veterinary Medical Association 193(2):211-214.

Harmon, J. 1995. Classy vermin: controlling rodents in schools. Pest Control Technology 23(9):38,40,49,52,54,112.

Harwood, R.F. and M.T. James. 1979. Entomology in Human and Animal Health, Seventh Edition. Macmillan, New York, NY. 548 pp.

Howard, W.E. and R.E. Marsh. 1967. The rat: its biology and control. University of California, Davis. Division of Biological Science, Cooperative Extension Service (Leaflet 2896). 22 pp.

Hygnstrom, S.E., R.M. Timm and G.E. Larson. 1994. Prevention and Control of Wildlife Damage. University of Nebraska, Lincoln.

Ingles, L.G. 1965. Mammals of the Pacific States, California, Oregon, and Washington. Stanford University Press, Stanford, CA. 506 pp.

Kundsin, R.B., ed. 1988. Architectural Design and Indoor Microbial Pollution. Oxford University Press, New York, NY.

Marsh, R.E. 1994. Roof rats. In: Prevention and Control of Wildlife Damage, pp. B125-B132. University of Nebraska, Lincoln.

Meehan, A.P. 1984. Rats and Mice: their biology and control. Rentokil Ltd., East Grinstead, England. 383 pp.

Moore, F., et al. 1988. Hypercalcemia associated with rodenticide poisoning in three cats. Journal of the American Veterinary Medical Association 193(9):1099-1100.

Olkowski, W., S. Daar, and H. Olkowski. 1991. Common-Sense Pest Control: Least-toxic solutions for your home, garden, pets and community. Taunton Press, Newtown, CT. 715 pp.

Pinto, L. 1992. Module III, vertebrates. In: Urban Integrated Pest Management: a guide for commercial applicators, Chapter 3, pp. 1-7. Dual & Associates Inc., Arlington, VA.

Quarles, W. 1995. Deer mice spread new hantavirus. Common Sense Pest Control Quarterly 11(1):13-15.

Scott, H.G. 1991. Design and construction: building out pests, pp. 331-343. In: Gorman, Ecology and Management of Food-Industry Pests. Association of Official Analytical Chemists, Arlington, VA.

Timm, R.M. 1983. House mouse. In: Hygnstrom, Timm and Larson, Prevention and Control of Wildlife Damage, pp. B17-B44. University of Nebraska, Lincoln.

Timm, R.M. 1994. Norway rats. In: Hygnstrom, Timm and Larson, Prevention and Control of Wildlife Damage, pp. B105-B120. University of Nebraska, Lincoln.

Timm, R.M. 1991. Chemical control of rodent pests in bulk-stored grains, pp. 419-426. In: Gorman, Ecology and Management of Food-Industry Pests. Association of Official Analytical Chemists, Arlington, VA.

Timm, R.M. and G.R. Bodman. 1983. Rodent-proof construction. In: Prevention and Control of Wildlife Damage, pp. B125-B131. University of Nebraska, Lincoln.

PART 2

Outdoor Pest Management

FUNGUS GNATS, SHORE FLIES, MOTH FLIES, AND MARCH FLIES

Integrated Pest Management in the Home, Interior Plantscapes, Greenhouses, and Nurseries

Fungus gnats, shore flies, moth flies, and March flies occur around damp, decaying vegetation, algae, and fungi. These flies can appear in large numbers in or around buildings, prompting complaints, and also can be a problem in greenhouses, nurseries, and interior plantscapes.

Fungus gnats infest soil and container media, where larvae feed on organic matter and roots. Shore flies live in or on algal scum or very wet, decomposing organic matter and are common in greenhouses and outdoor areas where conditions are damp. Moth flies commonly occur in bathrooms or kitchens, where larvae feed on muck in shower and sink drains. March flies live outdoors and are a nuisance when large numbers are attracted to lights.

DAMAGE

Adult fungus gnats, shore flies, moth flies, and March flies primarily are a nuisance. March flies, for example, are so named because adults of some species appear in large numbers during spring and fly to windows or porch lights. Adults may swarm along roads, annoying motorists by fouling windshields. Although March flies can enter buildings, they do not reproduce or develop in buildings. Fungus gnats and moth flies, however, can both enter buildings as flying adults and develop indoors through all life stages. Shore flies are unlikely to reproduce indoors, except in greenhouses. Fungus gnats, shore flies, moth flies, and March flies do not bite people or animals and, in the United States, are not known to carry human pathogens.

Only fungus gnats commonly damage plants (Fig. 1). Larvae of these flies feed on roots, thus stunting plant growth. Root damage can occur in interior plantscapes and in houseplants if high populations infest moist, organic-rich soil. Fungus gnat larval damage can be especially serious in greenhouses, nurseries, and sod farms. In addition to larvae chewing on roots, both larvae and adults can spread plant pathogens and may promote disease in commercial crops.

Abundant numbers of adult shore flies can leave unsightly frass spots (fecal droppings) on foliage. Root feeding by larvae is relatively uncommon. Shore flies may spread soil-dwelling pathogens, but this is uncertain and may be of little importance. Shore flies are frequently confused with fungus gnats, and they often occur together. Fungus gnats are usually more important pests, because they damage plant roots.

Moth fly larvae sometimes chew plant roots in greenhouses, but this is relatively uncommon. Moth flies in buildings feed primarily inside drain pipes but are not damaging to plumbing.

Although larvae of these species may feed on plant roots outdoors, none causes serious damage outside the home. Any root feeding by these species in gardens or landscapes is usually

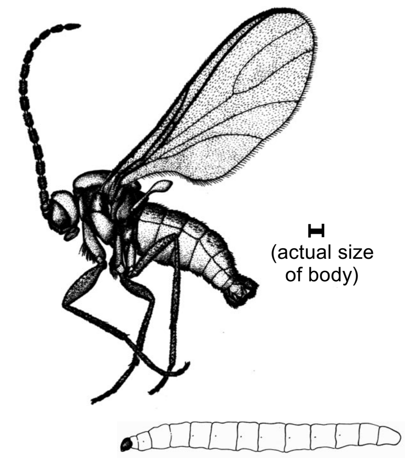

Figure 1. Fungus gnat adult and larva.

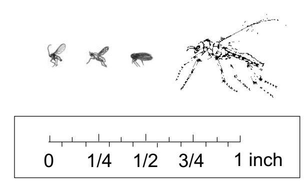

Figure 2. Relative sizes of (from left) fungus gnat, shore fly, moth fly, and March fly.

minor in comparison with their beneficial role as decomposers in helping to convert dead vegetation into nutrients for plant growth.

IDENTIFICATION

Fungus gnats (families Mycetophilidae and Sciaridae), shore flies (family Ephydridae), moth flies (family Psy-

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chodidae), and March flies (family Bibionidae) are all flies (order Diptera). The adults are sometimes confused with each other (Fig. 2) and with species in other families of small flies not discussed here, including black flies (family Simuliidae), midges (family Chironomidae), and mosquitoes (family Culicidae). If you are unable to determine what kind of fly you have, take samples to your county Cooperative Extension office or university entomology department for identification. Some nurseries and garden supply stores will also help you identify flies.

Fungus Gnats

Adult fungus gnats are dark, delicate-looking insects, similar in appearance to mosquitoes. Adult fungus gnats have slender legs with segmented antennae that are longer than their head. Although a few species are up to ½ inch long, adults commonly are about 1/16 to ⅛ inch long. Wings are light gray to clear; the common *Bradysia* species have a Y-shaped wing vein as illustrated in Figure 1. Fungus gnats are relatively weak fliers and usually are not found flying around indoors. They generally remain near potted plants and often run or rest on growing media, foliage, or litter.

Females lay tiny eggs in moist organic debris or potting soil. Larvae have a shiny black head and an elongate, whitish to clear, legless body. They eat organic mulch, leaf mold, grass clippings, compost, root hairs, and fungi. If conditions are especially moist and fungus gnats are abundant, larvae can leave slime trails on the surface of media that look like trails from small snails or slugs.

Shore Flies

Adult shore flies, like the common species *Scatella stagnalis*, are robust with short legs (Fig. 3). Antennae are bristlelike, shorter than the head, and not obvious. Their wings are dark, with five light spots. Shore flies are stronger, faster fliers than fungus gnats but are less likely to take flight than the more easily disturbed fungus gnats.

Shore fly larvae have a plump, brownish yellow, maggotlike or wedge-shaped, legless body, up to about ⅛ inch long. Larvae have no distinct head capsule, but their dark mouthparts and internal organs may be visible through their outer skin. Shore fly larvae have a distinctive forked, dark-tipped breathing tube at their tail. Shore flies have several generations each year.

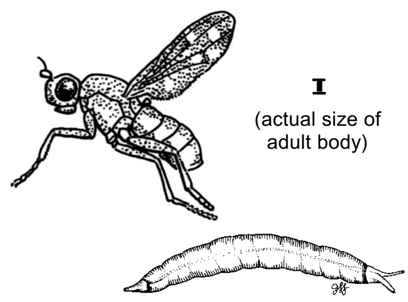

Figure 3. Shore fly adult and larva.

Moth Flies

Moth flies are also called drain flies, filter flies, or sewer flies. Adults appear grayish or dark because of the many fine hairs covering their wings and body (Fig. 4). Moth flies indoors are commonly observed resting with their wings held rooflike over their body on bathroom walls and around drain surfaces.

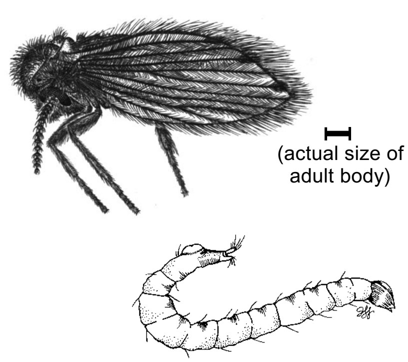

Figure 4. Moth fly adult and larva.

Mature larvae are less than ¼ inch long. They are somewhat flattened, have a distinct head, and small suction discs along their underside for adhering to slippery surfaces. Like other fly larvae, they have no true legs. Larvae feed in decaying organic matter, commonly within drains on the gelatinous film underneath drain plugs and screens and inside of pipes.

March Flies

March flies are usually dark brown or black, although the midbody of some species is reddish or orange. Its head points downward and is relatively small in comparison with body size (Fig. 5). Most adults are larger than the other flies discussed here; about ⅜ inch is a common size. March flies are relatively slow fliers and usually remain within a few feet of the ground. Adults may be seen on the ground or on sidewalks lying on their back struggling to upright themselves. Mating pairs of some species spend long periods flying or resting with their tails linked together. In Florida and Gulf Coast states where March flies are especially abundant, they are called lovebugs.

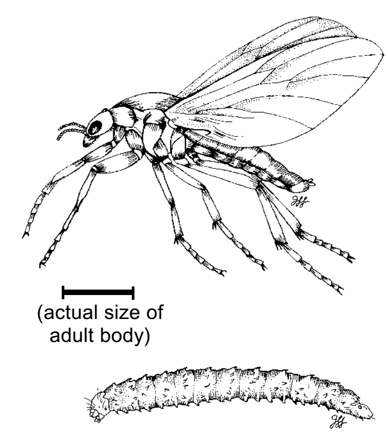

Figure 5. March fly adult and larva.

The larva is ⅜ to 1 inch long at maturity. It has a legless, cylindrical body that is dirty white, yellowish, or dark brown, with short spinelike projections

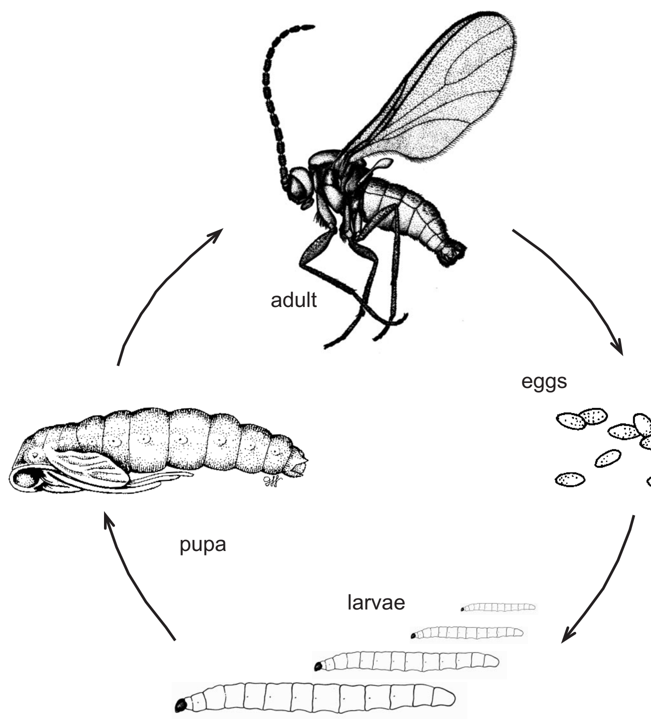

Figure 6. Life cycle of a fungus gnat.

on most segments and a distinct dark brownish head. March fly larvae feed primarily on decomposing plant matter including vegetables and fruit, but have also been found (at nondamaging levels) feeding on grass roots in lawns.

LIFE CYCLE

All four flies develop through four stages as illustrated for fungus gnats: egg, larvae (four larval stages or instars), pupa, and adult (Fig. 6). Fungus gnats, shore flies, and moth flies have many generations each year. Outdoors they are most common during winter and spring in interior areas of California. They occur anytime of year in moist coastal regions and indoors. Some species of March flies have only one generation a year. Each March fly species tends to be abundant during a certain season, usually spring.

Adults feed very little, consuming only liquids, such as water or flower nectar. The tiny eggs and oblong pupae occur in damp places where larvae feed.

MANAGEMENT

Physical and cultural methods—primarily screening windows and doors as well as reducing moisture and organic debris—are recommended for managing all of these flies. Biological control agents are also available to control fungus gnats. Insecticides are used in commercial plant production, but are not generally recommended for control around the home. Most of these insects' life span is spent as larvae and pupae in organic matter or soil, so most control methods target the immature stages, not the mobile and short-lived adults.

Monitoring

Visual inspection for adults is usually adequate to determine whether there is a problem. Adults can be observed resting on plants, soil, windows, or walls, or they may be seen in flight. Besides looking for adults, check outside near buildings for excessively moist conditions and organic debris where larvae may be feeding. These are the places to take control actions, as discussed in "Cultural Control." Yellow sticky traps or potato pieces for monitoring may be warranted as discussed in "Management Tools for Professionals" if you suspect that container plants or interior plantscapes are infested with fungus gnats or shore flies.

Cultural Control

Fungus gnats, shore flies, moth flies, and March flies thrive under moist conditions, especially where there is an abundance of decaying vegetation and fungi; avoid overwatering and provide good drainage. Allow the surface of container soil to dry between waterings. Clean up free-standing water and eliminate any plumbing or irrigation system leaks. Moist and decomposing grass clippings, compost, organic fertilizers, and mulches are favorite breeding spots. Avoid using incompletely composted organic matter in potting media unless it is pasteurized first, because it often is infested with fungus gnats. Minimize organic debris around buildings and crops where larvae feed. Avoid fertilizing with excessive amounts of manure, bloodmeal, or similar organic materials.

Physical Control

Keep doors, vents, and windows closed or screened to prevent insects from flying into buildings. Do not bring plants with infested soil indoors. Periodically turn and aerate compost piles where fly larvae feed. Locate compost away from doors and windows and keep it covered. Purchase and use only pasteurized container mix or treat potting soil with heat or steam before using it; this will kill flies as well as the algae and microorganisms they feed on. Store pasteurized potting soil in closed containers to prevent it from becoming infested before use. Generally the only control needed for moth flies developing indoors is to fix leaking plumbing and clean muck that collects in drains or under dripping taps. Brush or wash away slime under drain plugs, screens, and inside the top of drain pipes, above the water level in the J-trap (the U-shaped pipe under sinks).

Biological Control

Predators, such as rove beetles (family Staphylinidae) and ground beetles (family Carabidae), help control fly larvae outdoors in areas not sprayed with broad-spectrum insecticides. Commercially available *Steinernema* nematodes, *Hypoaspis* mites, or the biological insecticide *Bacillus thuringiensis* subspecies *israelensis* (Bti) can be applied to control fungus gnat larvae in container media.

Nematodes can provide relatively long-term control of fungus gnat larvae and they can be self-reproducing after several initial applications to establish their populations. *Steinernema feltiae* is apparently more effective against fungus gnats than other commercially available nematode species. Bti does not reproduce or persist; infestations in media may require repeated applications at about 5-day intervals to provide control. Mix Bti or nematodes with water and apply as a soil drench or spray onto media using conventional spray equipment.

Chemical Control

Insecticides are rarely, if ever, warranted to control these flies around homes. However, if insecticides are required for fungus gnats, consider using *Bacillus thuringiensis* subsp. *israelensis* or *Steinernema feltiae* nematodes to control the larvae in plant containers (see "Biological Control").

If Bti or nematodes are not available and high populations are intolerable, pyrethrins or a pyrethroid can provide temporary, fast-acting control. Pyrethrins have low toxicity to people and pets and are the active ingredients in the botanical pyrethrum, from flowers of certain chrysanthemums. Pyrethroids (e.g., bifenthrin, permethrin) are synthesized from petroleum to be chemically similar to pyrethrins, but often are more effective and persistent, as well as being more toxic to beneficial insects. When using these on houseplants or interiorscape containers, it may be best to move plants outdoors for treatment and wait about a day after application before bringing them back inside.

MANAGEMENT TOOLS FOR PROFESSIONALS

In commercial situations, management options include those discussed in Table 1, special monitoring methods, and insecticides. When using biological pesticides to control these pests, apply them as soon as fungus gnats are present. If large populations of fungus gnats are already present, these materials may be less likely to provide satisfactory control. A good monitoring program will help detect fungus gnat populations when they are at low levels.

Potato Cubes or Slices

Fungus gnat larvae migrate to feed on the underside of potato pieces placed in media. To determine whether container media are infested, use 1-inch cubes or slices of peeled raw potato imbedded about ⅜ inch deep into media. Pick up and examine the underside of each potato and the soil immediately beneath it about once or twice a week. Compare numbers of larvae before and after any treatment to determine whether larvae are being controlled.

Sticky Traps

Bright yellow traps, 3 x 5 inches or larger, are used to detect and identify flying insects. Traps containing insects can be wrapped with clear plastic (e.g., Saran Wrap) and taken to an expert for identification. Numbers of insects caught are not often a good indication of the number of pests infesting plants. Sticky traps are unlikely to provide pest control.

Orienting traps horizontal to the ground (facing the soil) is sometimes recommended when monitoring fun-

Table 1. Commercially Available Biological Pesticides and Natural Enemies for Controlling Fungus Gnat Larvae.

Biological: *Bacillus thuringiensis* subspecies *israelensis* (Bti) (Gnatrol)

Comments: A naturally occurring, spore-forming bacterium produced commercially by fermentation. Bti applied at labeled rates provides temporary control and is toxic only to fly larvae, such as mosquitoes, black flies, and fungus gnats. Repeat applications commonly are needed for long-term control. This Bt is a different subspecies from that applied to foliage to control caterpillars. Bt labeled for caterpillars is not effective against fly larvae.

Biological: *Hypoaspis* (=*Geolaelaps* or *Stratiolaelaps*) *miles*

Comments: A light brownish predaceous mite adapted to feeding in the upper layers of moist soil. Preys on fungus gnat larvae and pupae, thrips pupae, springtails, and other tiny invertebrates. Commercial mites commonly are shipped in a shaker type container used to apply them. Recommended rates in commercial nurseries are about one-half dozen to several dozen mites per container or ft^2 (0.1 m^2) of media. Make applications before pests become abundant. *Hypoaspis* probably will not perform very well in individual houseplants and probably is not a good choice for use in homes.

Biological: *Steinernema feltiae*

Comments: Nematode effective when temperatures are between 60° to 90°F (16° to 32°C) and conditions are moist. Can be applied as a soil drench and to media using conventional spray equipment. Nematodes reproduce and actively search for hosts, so under moist conditions they may provide season-long control after several initial applications to establish populations.

NOTE: These materials are essentially nontoxic to people and are compatible for application in combination. Bt and nematodes are available from many well-stocked nurseries and garden supply stores. Predaceous mites, and also Bti and nematodes, are commercially available through mail order from special suppliers (see *Suppliers of Beneficial Organisms in North America*, listed in "References").

gus gnats emerging from media. Vertical trap orientation (perpendicular to the soil surface) is more efficient overall if traps are also being used to monitor adults of other kinds of insects. Orient vertical traps so their bottom is even with the top of the plant canopy. Regularly adjust traps upward as plants grow. Hang traps from wires or use clothespins to clip the trap to a stick placed in media. Inspect traps at the same regular interval, once or twice a week. Count and record the number of each type of pest caught. Counting only the insects in a vertical, 1-inch-wide column on both sides of the trap gives results that are representative of the entire trap. Do not reduce trap size to 1-inch vertical strips.

Insecticides

Insect growth regulators (e.g., azadirachtin, kinoprene, diflubenzuron, cyromazine) applied to container media can be the most effective insecticides for controlling larvae. Drenching media with an organophosphate (acephate, malathion) or carbamate (carbaryl) also kills larvae, but this can be hazardous and will kill many different organisms, including beneficial species. For greenhouse applications, be sure the label specifically allows this use. Strictly follow all directions and precautions on the pesticide label.

Hydrated lime and certain registered materials like Agribrom and copper hydroxide are available to control algae under and around container-grown plant benches. Good control of algae can largely eliminate shore flies and may help to control fungus gnats and moth flies. Agribrom is effective and easy to use when applied through greenhouse irrigation systems at a rate of 10 to 35 ppm bromine for an initial application, followed at the recommended intervals by 5 to 10 ppm treatments as maintenance applications. These rates are generally not phytotoxic and give effective control.

Copper hydroxide can be applied about once per month as labeled. A slurry of 1 to 1½ pounds lime per gallon of water applied about every 3 to 4 months controls algae. Prevent contact with plants because copper hydroxide can be phytotoxic. Some counties may restrict growers' use of hydrated lime. Avoid contaminating water with these materials.

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REFERENCES

Dreistadt, S. H., J. K. Clark, and M. L. Flint. 2001. *Integrated Pest Management for Floriculture and Nurseries.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3402.

Ebeling, Walter. 1975. *Urban Entomology*. Oakland: Univ. Calif. Agric. Sci.

Harris, M. A., R. D. Oetting, and W. A. Gardner. 1995. Use of entomopathogenic nematodes and a new monitoring technique for control of fungus gnats, *Bradysia coprophila* (Dipt.: Sciaridae), in floriculture. *Biological Control* 5:412–418.

Hunter, C. D. 1997. *Suppliers of Beneficial Organisms in North America.* Calif. Dept. Pest. Reg., 830 K St., Rm 200, Sacramento, CA 95814. Available by phone (916) 324-4100 or online at http://www.cdpr.ca.gov/dprnews.htm

Robb, K. L., H. Costa, J. Bethke, R. Cowles, and M. P. Parrella. Feb 2001. Insects and Mites from *UC IPM Pest Management Guidelines: Floriculture*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3392. Also available online at http://www.ipm.ucdavis.edu/PMG/crops-agriculture.html

Wright, E. M., and R. J. Chambers. 1994. The biology of the predatory mite *Hypoaspis miles* (Acari: Laelapidae), a potential biological control agent of *Bradysia paupera* (Dipt.: Sciaridae). *Entomophaga* 39:225–235.

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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ILLUSTRATIONS:
Fig. 1 larva–17th St. Studio; adult–from Gorham, J. R., ed. 1991. *Insect and Mite Pests in Food: An Illustrated Key*. Washington, D.C.: U. S. Dept. Agric. Handb. 655
Fig. 2–adapted from other figures.
Fig. 3 larva–J. L. Lockwood; adult–17th St. Studio
Fig. 4 larva–J. L. Lockwood; adult–from Gorham, J. R., ed. 1991. *Insect and Mite Pests in Food: An Illustrated Key*. Washington, D.C.: U. S. Dept. Agric. Handb. 655
Fig. 5 J. L. Lockwood
Fig. 6 eggs and pupa–J. L. Lockwood; larvae–17th St. Studio; adult–from Gorham, J. R., ed. 1991. *Insect and Mite Pests in Food: An Illustrated Key*. Washington, D.C.: U. S. Dept. Agric. Handb. 655

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GLASSY-WINGED SHARPSHOOTER

Integrated Pest Management for Home Gardeners and Landscape Professionals

The glassy-winged sharpshooter, *Homalodisca coagulata*, is an insect that was inadvertently introduced into southern California in the early 1990s. This insect is native to the southeastern United States and was most likely accidentally brought into California as egg masses in ornamental or agricultural plant foliage.

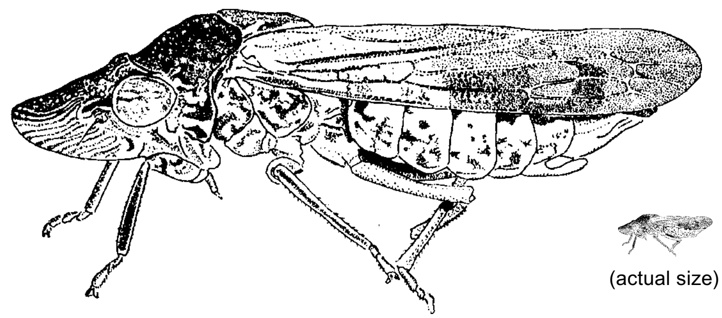

Figure 1. Female glassy-winged sharpshooter.

THE PROBLEM

The glassy-winged sharpshooter is a large leafhopper that obtains its nutrients by feeding on plant fluids in the water-conducting tissues of a plant (the xylem). Feeding on plants rarely causes significant plant damage, although the insects do excrete copious amounts of liquid that can make leaves and fruit appear white washed when it dries. The excrement is a special nuisance when shade trees are heavily infested because cars parked under the trees tend to become spotted. During hot weather, heavy populations of glassy-winged sharpshooters feeding on small plants may cause them to wilt. For a list of plants that host the glassy-winged sharpshooter, see the California Department of Food and Agriculture (CDFA) Web site listed in "Online References."

The real problem associated with glassy-winged sharpshooter, however, is that it can spread the disease-causing bacterium *Xylella fastidiosa* from one plant to another. This bacterium is the causal agent of devastating plant diseases such as Pierce's disease of grape, oleander leaf scorch, and almond leaf scorch. Outside California, other strains of *Xylella fastidiosa* cause phony peach disease, plum leaf scald, and variegated citrus chlorosis, but these diseases have not been detected in California. At the present time there is no cure for any of these diseases. For more information on oleander leaf scorch, see the *Pest Notes: Oleander Leaf Scorch* listed in "References."

When a glassy-winged sharpshooter feeds on a plant that is infected with *Xylella fastidiosa*, it acquires the bacteria, which then multiply within the insect's mouthparts. The sharpshooter then transfers the bacteria to another plant when it feeds. For more information about *Xylella fastidiosa* see the Web sites listed in "Online References." It is important to note that *Xylella fastidiosa* can reside in many plants, such as bermudagrass, without causing a disease.

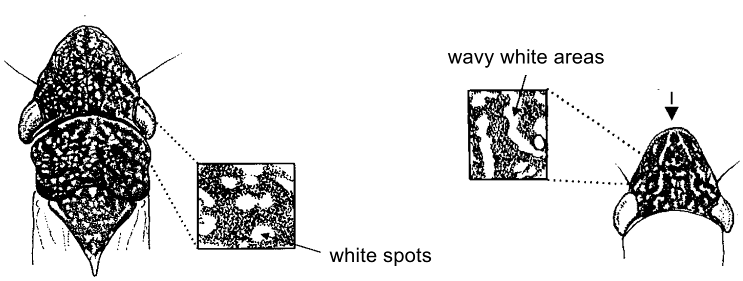

Figure 2. Detail of head of glassy-winged sharpshooter (*left*) and smoke-tree sharpshooter (*right*).

IDENTIFICATION AND BIOLOGY

The glassy-winged sharpshooter is a large insect compared to other leafhoppers. Adults are about ½ inch long and are generally dark brown to black when viewed from the top or side (Fig. 1). The abdomen is whitish or

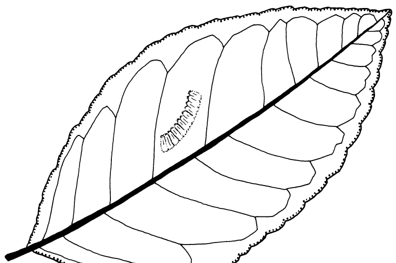

Figure 3. Glassy-winged sharpshooter egg mass in lower surface of leaf.

yellow. The head is brown to black and covered with numerous ivory to yellowish spots (Fig. 2). These spots help distinguish glassy-winged sharpshooter from a close relative, smoke-tree sharpshooter (*H. lacerata*), which is native to the desert region of southern California. The head of the smoke-tree sharpshooter is covered with wavy, light-colored lines, rather than spots (Fig. 2). Immature stages (nymphs) of the glassy-winged sharpshooter look similar to the adults except they are smaller, wingless, uniform olive-gray in color, and have prominent bulging eyes.

Females lay their eggs in masses of about 10 to 12 in the lower leaf surface of young, fully developed leaves. When it is first laid, the egg mass appears as a greenish blister on the leaf (Fig. 3). The female covers the leaf blister with a secretion that resembles white chalk and is more visible than the leaf blister. Shortly after the eggs hatch, the leaf tissue begins to turn brown. The dead leaf tissue remains as a permanent brown scar.

Nymphs hatch in 10 to 14 days and proceed to feed on the leaf petioles or small stems while they progress through five molts before becoming winged adults. In southern California, there are generally two peaks of adult activity, one in the summer (first generation) from late June through July and another from late fall through the winter (second generation). Adults of the second generation spend the winter feeding in citrus and other evergreens and can move to deciduous plants in January and February, returning to the evergreens during cooler evening hours. These overwintered adults begin laying eggs in February but lay most of their eggs in late March and April; peak egg laying for the second generation occurs in July and August.

Glassy-winged sharpshooter has become established in most of southern California and in certain localized sites in central and northern California. There is great concern that this insect may eventually invade most California counties. Figure 4 shows the areas in California where this sharpshooter has been found and counties where it is feared that the pest may spread. California county agricultural commissioners are following this pest closely. For the most recent information, see the CDFA Web site listed in "Online References."

MANAGEMENT

The principal reason for controlling the glassy-winged sharpshooter is to prevent the spread of the *Xylella* bacterium to susceptible plants. Because very low numbers of sharpshooters can spread the disease, it is not known how effective insecticides applied to suppress sharpshooters will be in controlling disease spread; research is currently underway to study this issue.

The current strategy for containing the problem is to keep the insect out of new areas. This requires careful monitoring and detection as described below. If glassy-winged sharpshooter is found in an area not currently known to have this pest, immediately contact the local agricultural commissioner's office (the address and phone number are usually found in the telephone directory under "County Government").

In areas where the glassy-winged sharpshooter is established, efforts are underway to bring in biological control agents for long-term management. Chemical treatments can be applied to reduce glassy-winged sharpshooter numbers but are generally not required

Figure 4. Distribution of glassy-winged sharpshooter in California as of June, 2001. Infested areas are dot filled and "at risk" areas are lined.

to protect the health of plants not susceptible to the *Xylella fastidiosa* bacterium.

Detection and Monitoring

Even though this insect is large enough to be seen with the naked eye, it is very inconspicuous in nature. The brown coloration of the insect blends very well with the color of the twigs where it is usually found, and it hides by moving to the other side of the twig or branch when it detects movement or is otherwise approached or disturbed. Leaves or fruit coated with a whitish, powdery material may indicate that there has been heavy glassy-winged sharpshooter feeding on that plant. Large, yellow sticky traps are commonly used in orchards to monitor for the adults. Sweep nets are also used to monitor for glassy-winged sharpshooter in agricultural situations. Glassy-winged sharpshooter infestations can also be determined by examining the underside of plant leaves for egg masses.

Cultural Control

There are no known cultural controls for glassy-winged sharpshooter, but its spread in California can be slowed by preventing transport of infested plant material to areas where glassy-winged sharpshooter has not been found. Nurseries shipping plants out of an infested area must follow rigorous plant inspection and treatment before the plants are shipped and then the plants must be inspected again after they arrive at their destination.

Biological Control

Only one group of biological control agents of any significance has been noted to date. Small egg parasites in the *Gonatocerus* genus attack glassy-winged sharpshooter egg masses starting in spring. The rate of parasitism gradually increases over the season. During the first period of egg laying in late April to May, parasitism is usually between 10 to 50%, but during the second egg-laying period in late summer and early fall, it can reach as high as 90 to 100%. Eggs parasitized by these tiny wasps are easily identified by the pinpointlike holes found at one end of the egg (Fig. 5). Work is currently underway to find additional biocontrol agents.

Chemical Control

In areas where glassy-winged sharpshooter is not well established, local agricultural commissioners will treat infestations with carbaryl or other materials such as pyrethroids or imidacloprid in an attempt to eradicate this pest if it is found.

Where glassy-winged sharpshooter is established, insecticide treatments to reduce populations of this pest may be used on *Xylella*-susceptible plants to slow the spread of the disease. Management of glassy-winged sharpshooter is not normally recommended on plants not susceptible to disease because the pest causes limited damage. However, on lemon, a preferred host, both yield and fruit quality are reduced after season-long infestations of high populations (more than 100 glassy-winged sharpshooters per tree).

The main material used to protect *Xylella*-susceptible plants is imidacloprid, which is registered for home and landscape use on nonfood crops. Imidacloprid is sold in two formulations: one for soil application and one for foliar application. The soil-application formulation provides the most effective, long-lasting control and will not disrupt the biological control provided by the parasitic wasps, but it takes several weeks to become effective. Foliar applications of this material are effective for a much shorter period of time and may disrupt biological control agents.

In instances where the white excrement produced by this pest is causing intolerable residues on cars or other surfaces, other insecticides can be applied to infested foliage to provide immediate relief. The least toxic and disruptive to biological control are insecticidal soaps and oils. Insecticidal soaps and oils are only effective in killing the soft-bodied nymphs of the glassy-winged sharpshooter and must directly contact the insect to kill it, so thorough coverage of the plant or tree foliage is essential. Applications of these materials need to be repeated at about 7- to 10-day intervals. Pyrethrin plus piperonyl butoxide, carbaryl (Sevin), and pyrethroids (e.g., cyfluthrin, permethrin) can also be used for foliar applications, but these materials are much more destructive to the parasitic wasps that are being introduced for biological control. While there is no residual control when pyrethrin with piperonyl butoxide is used, one application of the other two materials usually provides control for about 5 weeks.

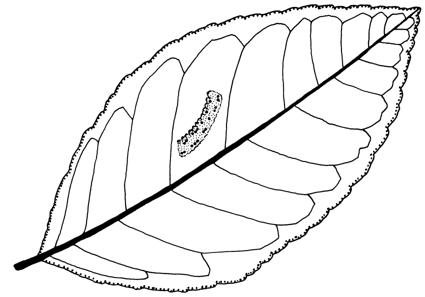

Figure 5. Parasite emergence holes in glassy-winged sharpshooter egg mass.

REFERENCES

Varela, L. G., R. J. Smith, and P. A. Phillips. 2001. *Pierce's Disease*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 21600.

Wilen, C. A., J. S. Hartin, J. M. Henry, H. S. Costa, M. Blua, and A. H. Purcell. July 2000. *Pest Notes: Oleander Leaf Scorch.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 7480. Also available online at http://www.ipm.ucdavis.edu/PMG/selectnewpest.home.html

ONLINE REFERENCES

http://plant.cdfa.ca.gov/gwss/ for a current map of infested sites in Calif. and a partial list of host plants.

http://danr.ucop.edu/news/MediaKit/GWSS.shtml for the latest Univ. of Calif. news releases on glassy-winged sharpshooter and links to other UC Web sites on this topic.

For more information, contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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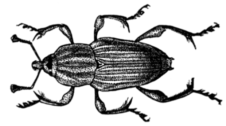
LAWN INSECTS

Integrated Pest Management for the Home Gardener

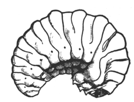
Insects are not a common cause of residential lawn damage in California, but certain species occasionally damage or kill turfgrass. Insect feeding can cause grass to turn yellow or brown, or die, especially if the grass is already stressed. Damage usually begins in small, scattered patches, which may merge into large dead areas. However, lack of proper cultural care and use of inappropriate grass species in a particular location are more likely responsible for unhealthy or dying lawns than insects. Disease-causing pathogens, excessive or inappropriate use of chemicals such as fertilizers and herbicides, and dog urine also produce damage resembling that of insects. Before taking any insect control action, be sure that it is insects causing the problem and not something else.

Insects that may cause damage in California lawns include various root-, crown-, and leaf-feeding caterpillars; white grubs, which are the larvae of scarab beetles such as the black turfgrass ataenius and masked chafers; billbugs, which are weevils with white, grublike larvae; and chinch bugs, which are true bugs in the order Hemiptera. Each species produces somewhat different damage symptoms and must be managed differently. Study Figure 1 for identifying characteristics and Table 1 for damage symptoms associated with each species. In addition to the pests in Table 1, leafhoppers may occur in lawns, sometimes causing yellowing of leaf blades, but rarely occur in numbers justifying treatment. Many other insects may be observed while examining grass. However, control is rarely or never needed for most types of insects because they are harmless or beneficial. Common beneficial insects include predatory ants, ground beetles, rove beetles, and blister

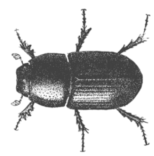
Figure 1. Identifying features of various lawn pests.



Billbug adult is a small weevil (snout beetle), 1/3 inch long, with a long, downward-pointing snout and elbowed, clubbed antennae. It is often seen walking on paved areas but is difficult to find in turf unless a drench test is used.

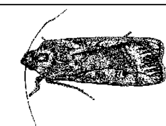


Billbug larva is a creamy white, legless, 3/8-inch-long grub with a brown head. The absence of legs distinguishes a billbug larva from a white grub larva.



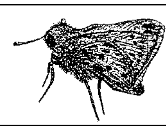
Black turfgrass ataenius adult is a shiny jet black beetle, 1/5 inch long, with club-end antennae

Chinch bug (southern) adult is small (less than 1/5 inch long) and black with mostly white wings folded flat over the body. Both long- and short-winged forms may be present. Nymphs are bright red to black.

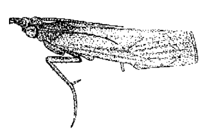


Armyworm and cutworm adults are dull brown or grayish, relatively large (up to 1 1/2 inches long), night-active moths.

Armyworm and cutworm larvae are up to 2 inches long at maturity; larvae often curl up and lie still when disturbed.

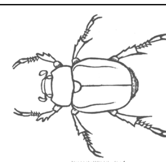


Skipper (fiery) adult is a 1-inch-long, orange to brownish butterfly with a hooked knob at the end of the antennae.



Lawn moth has an appendage in front of the head resembling a snout. Resting adults appear slender. When disturbed, the moth makes a short flight close to the grass. Adults are up to 3/4 inch long.

Sod webworm (lawn moth) larva is cream colored, 3/4 inch long, and has a distinctive double row of brown or black spots down its back, located at the base of long bristles.



White grub (chafer) adult is a golden brown, up to 3/4-inch-long beetle with a dark brown head; it is hairy on the underside of its thorax.

White grub larva has a distinct brown head capsule and legs, is up to 1 1/2 inches long; the posterior portion of its abdomen is enlarged, and it typically curls tightly into a C-shape.

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beetles. Other common arthropods that are primarily decomposers and do no significant injury to turfgrass include springtails and millipedes.

MANAGING LAWN INSECTS

Good cultural practices are the primary method for managing insect damage to lawns. Growing appropriate grass species for a particular location and providing lawns with proper care are especially important. Practices such as irrigating and fertilizing have a major impact on lawn health. Physical controls, such as thatch removal, choice of mowing height and frequency, and providing grass with more light by pruning tree branches, are also important in certain situations. Naturally occurring biological control may limit some insect pests. Most home lawns in California do not need to be treated with insecticides if proper cultural practices are followed. Insecticides should never be applied unless a pest is identified and detected at damaging levels. If insecticides are necessary, choose materials that have minimum impacts on beneficial organisms and the environment.

Preventing Pest Problems

The best way to prevent damage from lawn pests is to keep grass healthy. Healthy lawns require few, if any, insecticide treatments. Also, if the turfgrass is under stress and a pesticide is applied, it stands a greater chance of suffering phytotoxic damage from the pesticide itself. The publications on managing your lawn listed in "Suggested Reading" give detailed information on how to grow a healthy lawn.

Choose Appropriate Varieties. There are a number of grasses available for planting in California. These grasses are often referred to as either cool-season grasses (examples include annual ryegrass, bentgrass, fine fescue, Kentucky bluegrass, perennial ryegrass, and tall fescue) or warm-season grasses (bermudagrass, kikuyugrass, St. Augustinegrass, and zoysiagrass). Warm-season grasses produce most of their growth during summer and usually have a dormant period when they turn brown during winter. Cool-season grasses are green year-round, but produce most of their growth in spring and fall. The type of grass and the varieties within each type vary in their shade tolerance, salinity tolerance, water needs, disease resistance, and cultural needs. A formerly thriving lawn variety may decline with changes in light, such as more or less shade caused by growth or removal of nearby trees. These factors are outlined in *Selecting the Best Turfgrass*, listed in "Suggested Reading." Selection of the appropriate grass species and variety will allow you to grow a hardy lawn with minimal maintenance inputs.

Care for Lawns Properly. Inappropriate irrigation is the most common cause of lawn damage. Overwatering (shallow, frequent sprinkling) retards deep root growth and increases lawn

Table 1. Some Lawn Pests, Appearance of Their Damage, and Cultural Control Methods.

Pest (Scientific name)	Hosts	Damage appearance	Cultural control
armyworms, cutworms (*Pseudaletia unipuncta, Peridroma saucia, Agrotis* spp.)	all grasses, dichondra	leaves and base of leaves chewed and cut beginning in small, irregular spots that can spread to patches extending many feet in width	reduce thatch; eliminate soggy areas; overseed lawn
billbugs (*Sphenophorus* spp.)	all grasses	brown, thin, dying grass, beginning in small, irregular spots that can spread to patches extending many feet in width	irrigate and fertilize adequately; increase mowing height
black turfgrass ataenius (*Ataenius spretulus*)	annual bluegrass, bentgrass, ryegrass, Kentucky bluegrass	brown, dying grass, few roots; lawn is easily peeled off soil	increase mowing height; aerate to improve root growth
fiery skipper (*Hylephila phyleus*)	bentgrass, bermudagrass, St. Augustinegrass	1- to 2-inch-diameter spots of lawn turn brown; spots may join to form large, irregular dead patches; leaves chewed or missing	reduce thatch; overseed with grass species that are not preferred
lawn moths, sod webworms (*Crambus sperryellus, Tehama bonifatella*)	all grasses, especially bentgrass, bluegrass, clovers	lawn brown; leaves chewed or missing	reduce thatch; irrigate and fertilize appropriately
southern chinch bug (*Blissus insularis*)	primarily St. Augustinegrass	irregular patches of lawn turn yellowish, then brown and begin dying during hot weather	reduce thatch; reduce nitrogen fertilization; irrigate adequately; plant resistant varieties such as Floralawn, Floratam, or FX-10 if growing St. Augustinegrass
white grubs—immatures of masked chafers (*Cyclocephala* spp.), May and June beetles (*Phyllophaga* spp.)	all grasses, especially bluegrass, ryegrass	brown dying grass; lawn can be rolled up if heavily infested	irrigate and fertilize appropriately; overseed lawn

Some pests specific to bermudagrass and dichondra are not included in this table. Other invertebrates that occasionally damage lawns include crane flies, frit flies and other flies, flea beetles, leafhoppers, Lucerne moths, plant bugs, mealybugs, scale insects, and mites. Adapted from Ali and Elmore (1989) and Costa et al. (2000); for more information consult publications in "Suggested Reading."

susceptibility to stress. Poorly maintained sprinklers can apply too much water in certain spots while under-watering other areas. Brown spots from uneven water applications occur frequently and are often caused by improperly spaced irrigation heads, sunken or tilted heads, or unmatched heads that apply differing amounts of water. Correcting these physical problems with irrigation systems can decrease water waste by over 50%, decrease water bills, and most importantly, improve the health of your lawn. Lawns should be irrigated deeply and no more often than twice a week.

Appropriate fertilization encourages a dense, thick lawn that allows grass to tolerate some insect feeding. The appropriate timing and amount of fertilizer (primarily nitrogen) varies depending on factors including season, grass species, and local growing conditions. In general, most California grasses used for lawns require from 3 to 6 pounds of actual nitrogen over a 1,000-square-foot area annually during their active growing season.

Keep the blades on your lawn mower sharp and cut your turf at a mowing height appropriate for the type of lawn grass to minimize depletion of food reserves needed to outgrow insect injury. Mowing frequency and height depend on grass species, season, and the particular use of that lawn. Cool-season lawns have suggested mowing heights of 1½ to 2½ inches, while warm-season lawns should be mowed to a height of ¾ to 1 inch. No more than one-third of the grass height should be removed at one time.

Lawns also benefit from aeration. To increase water penetration and reduce soil compaction, periodically remove soil plugs using hollow tines. Thatch, which is the layer of undecomposed organic material on the soil surface, can build up and result in poor water, fertilizer, and air penetration. Thatch that is greater than ½ inch thick encourages caterpillar and chinch bug populations. Thatch also reduces insecticide efficacy because insecticides cannot penetrate to reach root-feeding insects. Prevent thatch by avoiding excess nitrogen application, irrigating deeply and infrequently, and minimizing the use of lawn pesticides that can reduce populations of microorganisms responsible for decomposing the thatch. If it is more than ½ inch thick, physically remove thatch with a garden rake, mechanical dethatcher, vertical mower, or power rake. Other methods include topdressing lawns by adding a thin layer (⅛–¼ inch) of soil and raking or sweeping it into the thatch to encourage decomposer microorganisms. Core aerification also mixes soil into thatch, speeding decomposition.

Biological Control

Certain insects, other invertebrates, and microorganisms that occur naturally in lawns feed on or parasitize lawn pests. This type of control, called biological control, may help to prevent many lawn-dwelling insects from becoming pests. To protect beneficial insects, avoid using broad-spectrum pesticides that will kill them along with the pests. Biological pesticides containing organisms such as *Bacillus thuringiensis* (Bt) and beneficial nematodes are commercially available for controlling specific lawn insects. These materials have minimal impacts on natural enemies of insect pests and other beneficial organisms such as earthworms. Birds, moles, and other vertebrates also feed on lawn insects from time to time.

Detecting Problems in Your Lawn

Examine your lawn weekly or just before each mowing to detect problem areas. At the same time, look for weeds. A dense stand of healthy grass prevents most weeds from growing, so abundant weed growth indicates that the lawn is unhealthy and susceptible to other pests. New turfgrass is especially vulnerable to problems and has different irrigation and fertilizer requirements than established turfgrass. An indication that a lawn may be infested with insects is when the adults (e.g., moth or beetle stage) of pests are drawn to lights at night or when vertebrate predators (birds, raccoons, or skunks) are digging in your lawn for caterpillars and grubs. However, the insects coming to light may be drawn from far away and vertebrate activity is not a foolproof indicator. They may be feeding on earthworms instead of insects; also, vertebrates will return to where they previously found food, so they may dig in lawns even if insect pests are no longer abundant.

If you observe damage, the next step is to determine the actual cause**.** If you think the damage is caused by insects, confirm your suspicions by looking for the pest. The most accurate way to do this is by using either the drench test or by inspecting around roots (Table 2). The drench test is effective for detecting chinch bugs and caterpillars including armyworms, cutworms, and sod webworms, but it does not detect grubs. Locating and correctly identifying a pest is important because different pests require different treatment materials, timing, and application methods.

Identify the insects you find using descriptions in this publication (Fig. 1) and other publications such as *Handbook of Turfgrass Pests* or *Turfgrass Pests* listed in "Suggested Reading." The *UC IPM Pest Management Guidelines: Turfgrass* is available on the World Wide Web *(www.ipm.ucdavis.edu/PMG/selectnewpest.turfgrass.html)* and contains color photos of some turfgrass pests. After identifying the insects, count the number of each type of insect found. Some of the insects you find may be beneficial or nondamaging. In home lawns, you usually need only to be concerned with the insects listed in Table 1.

Remember that the mere presence of an insect pest does not imply that it is the cause of unhealthy lawns or that an insecticide treatment is needed. It is normal to find a few pest insects in any healthy lawn. Generally treatments are not recommended unless the population level of the insect pest reaches a predetermined level called a *threshold* (Table 2). Thresholds are the population levels at which the number of insects feeding exceeds the ability of a healthy lawn to withstand the damage they cause. For example, an insecticide usually is not needed unless there are more than about 5 armyworms and cutworms or 15 lawn moth larvae per

Table 2. Lawn Pest Detection Methods, Treatment Targets, Thresholds, and IPM-compatible Materials.

Insect	Detection method	Treatment target	Suggested treatment threshold	IPM-compatible materials
armyworms, cutworms	drench test for fat, dull gray, green, or brownish larvae up to 2 inches long; inspect outdoor lights around dawn for 1 1/4 inch brownish to gray moths	crowns, leaves, thatch	5/yd²	A, Bt, P, Sc
billbugs	dig around roots for whitish, C-shaped, legless grubs up to 3/8 inch long with reddish heads; inspect outdoor lights around dawn for 1/3 inch brownish to gray snout beetles	crown, roots	1/ft²	I, Sc
black turfgrass ataenius (see also white grubs)	dig around roots for whitish, C-shaped grubs up to 1/3 inch long with 6 legs and reddish heads; inspect outdoor lights around dawn for shiny black adults 1/5 inch long	roots, thatch soil interface	40/ft²	Hb, I, Sc
chinch bug, southern	drench test or inspect around grass bases for reddish, purple, black, or gray bugs up to 1/2 inch long	crowns, stems	135/yd² or 15 nymphs & adults/ft²	P
lawn moths (sod webworms)	drench test for slender, grayish larvae up to 3/4 inch long; whitish or brownish moths up to 3/4 inch long fly when grass is disturbed	crowns, leaves, thatch	15/yd²	A, Bt, P, Sc
skipper, fiery	drench test for larvae up to 1 inch long with pink-green body and red and black head; orangish butterflies 1 inch wide with knobbed antennae feed at flowers; mere presence of this insect does not warrant control	leaves, stems	15/yd²	Bt, Hb, P
white grubs (the immatures of masked chafers, May and June beetles; see also black turfgrass ataenius)	dig around roots in late winter or summer for whitish to yellow, wrinkled, C-shaped grub up to 1 1/2 inches long with 6 legs and a reddish head; look for yellowish brown adults 1/2 inch long.	roots	6/ft²	Hb, I, Sg

Check current labels for permitted uses and proper application methods.

Adapted from Ali and Elmore (1989) and Costa et al. (2000).

IPM-compatible materials
A = azadirachtin or neem (Safer BioNeem)
Bt = *Bacillus thuringiensis* (BT WormKiller, Caterpillar Clobber)
I = imidacloprid (Bayer Advanced Lawn Grub Control, GrubEx, etc.)
P = pyrethrin (Safer Yard & Garden Insect Killer)

Predaceous nematodes
Hb = *Heterorhabditis bacteriophora*
Sc = *Steinernema carpocapsae*
Sg = *Steinernema glaseri*

square yard. Sample several different areas of the lawn to better estimate populations overall, especially if numbers are close to suggested thresholds.

Drench Test. To detect chinch bugs, adult billbugs, and caterpillars including armyworms, cutworms, and larvae of lawn moths (sod webworms), perform a drench test by mixing 1 to 2 fluid ounces (2–4 tablespoons) of dishwashing liquid (such as Lemon Joy) to a gallon of water. If you are using a concentrate (i.e., Ultra) version of a dishwashing liquid, 1 1/2 tablespoons per gallon of water is adequate. Two gallons may be required where soils are dry.

Apply the solution to 1 square yard of lawn as evenly as possible using a sprinkling can (Fig. 2). Test an area that includes both relatively healthy grass and adjoining unhealthy grass. The drench will cause insects to move to the surface. During the next 10 minutes, identify and count the number of pest insects.

Inspect Around Roots. The drench test does not indicate the presence of billbug larvae, black turfgrass ataenius larvae, or white grubs (masked chafers, May beetles, and June beetles). To detect white grubs, dig or cut beneath thatch (Fig. 3) and examine the soil around roots and crowns (where roots and stems meet). Look for the white, legless larvae of billbugs (a weevil) or the C-shaped, six-legged larvae of scarab beetles such as black turfgrass ataenius and masked chafers. When these are numerous, roots are eaten away and turf often can be rolled back like a carpet. If you find more than about one billbug larva, six white grubs, or 40 black turfgrass ataenius grubs per square foot, control may be needed.

TREATMENT

If cultural practices are not enough to prevent damage, and a drench test or root inspection indicates treatment is warranted, choose selective, least toxic, IPM-compatible products (Table 2) whenever possible to control pests. The microbial insecticide *Bacillus thuringiensis* and insect-killing nematode products that can be applied like insecticides have minimal negative impacts on nontarget organisms. The insecticides azadirachtin, pyrethrum (pyrethrins), and imidacloprid are also

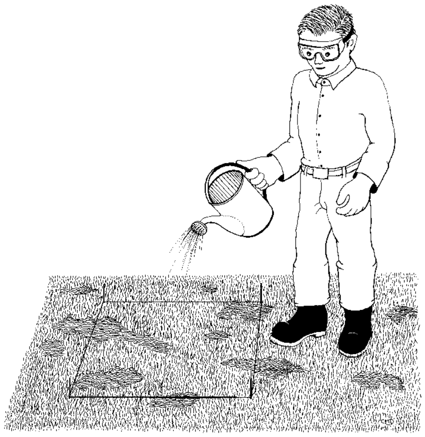


Figure 2. Detect chinch bugs, adult billbugs, and caterpillars by drenching a 1-square-yard area of lawn with a soap solution to irritate insects so they come to the surface.

relatively safe products for lawn insect management. Each of these products is effective only on certain pests and all must be properly timed and applied to be effective. Avoid the use of chlorpyrifos and diazinon; urban use of these materials has been identified as a source of pollution in California's creeks and rivers. Other broad-spectrum insecticides, including carbaryl, pyrethroids, and acephate, are available. However, these materials pose risks for beneficial and nontarget organisms. Use them only when IPM-compatible insecticides cannot control the infestation.

Avoid the use of lawn fertilizer products that also contain insecticides for preventative treatment. Insecticide treatment at the time of fertilizing is usually not justified and may reduce the presence of beneficial insects.

Mow the lawn and reduce excess thatch (greater than 1/2 inch) before applying insecticides. Unless otherwise directed on the product label, irrigate and allow grass blades to dry before treating caterpillars and other insects that feed on grass blades and stems. Do not treat if rainfall is expected and do not irrigate for at least 48 hours after spraying for leaf-feeders to allow the insecticide to remain on grass blades as long as possible. When treating white grubs and other root-feeders, wait to irrigate until after application so the insecticide is moved down into the soil.

Certain chemicals may injure lawns, especially if used on seedlings, when temperatures are too high, or if grass is stressed. Injury may also result from excess amounts, repeated applications, the wrong formulation, or from mixing incompatible materials. Inert ingredients, such as wetters, spreaders, emulsifiers, diluents, and solvents, may also injure lawns.

***Bacillus thuringiensis* (Bt).** Bt kills only caterpillars. When infected with Bt, caterpillars stop feeding within a day and usually die within a few days.

Unlike broad-spectrum insecticides that kill on contact, caterpillars must eat Bt-sprayed foliage to be killed, so proper timing and thorough spray coverage are very important. Bt is most effective on caterpillars when they are young. Once the caterpillars become large they are harder to kill with this material, and other control measures may be necessary. Apply Bt during warm, dry weather when caterpillars are feeding actively. Sunlight inactivates Bt on foliage, so make applications in the evening. Repeat treatment after about 7 to 10 days.

Nematodes. Insect-attacking nematodes can be applied to control caterpillars or grubs. Each nematode species is effective on a different range of pests. Select the nematode species most effective against the target pest(s) (Table 2). All nematode species are most effective when applied during the early part of the season for that pest (Fig. 4) when grubs or caterpillars are active. A second application about 2 weeks after the first increases the likelihood that nematodes will reproduce and provide long-term pest control. Irrigate before and after application. Apply to warm (at least 60°F), moist but not soggy soil. Several irrigations may be needed during the 2 weeks after each application to keep soil moist. Because nematodes are killed by light and heat, apply them in the evening, especially in hot areas.

Nematodes usually must be mail ordered. Because they are very perishable, store them as directed (usually under cool, dark conditions) and do not store them for long periods. Purchase from a reputable producer or supplier of fresh nematodes. Sources include those listed in the free pamphlet *Suppliers of Beneficial Organisms in North America* available from the California Department of Pesticide Regulation, 830 K Street, Sacramento, CA 95814-3510, phone 916-324-4100, or on the World Wide Web at *www.cdpr.ca.gov/dprnews.htm*. Suppliers and details on nematode use are also available at *http://www2.oardc.ohio-state.edu/nematodes.*

Azadirachtin. The botanical pesticide azadirachtin is extracted from the seeds of the neem tree. It is used to control cutworms, armyworms, and the larvae of lawn moths. Azadirachtin is absorbed by the plant and is able to move to a limited degree within the plant. Because azadirachtin acts partly as an insect growth regulator (i.e., it prevents the caterpillar from reaching maturity), most caterpillars are not killed until

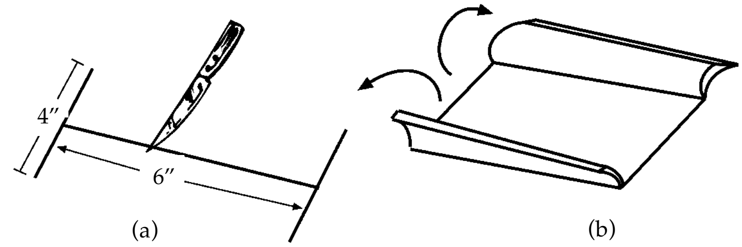
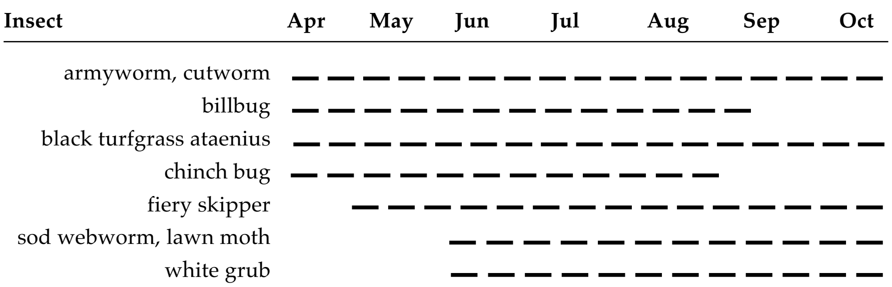


Figure 3. Detect billbug larvae, black turfgrass ataenius, and white grubs by digging around the root zone with a hand trowel. Alternatively, make three connected cuts through grass and thatch in the shape of a capital "I" (a); then lift back (b) and inspect underneath. If the area examined is 6 inches long and 4 inches wide, inspect six such areas to uncover a total of 1 square foot and compare the number of insects discovered to the suggested thresholds.

Figure 4. Approximate times to monitor for some lawn insects. Actual treatment time varies depending in part on location, temperature, rainfall, and the specific insecticide used. Before applying an insecticide, monitor for insects to confirm pest presence and that their numbers exceed thresholds.



several days after application, and azadirachtin's effectiveness is not immediately apparent.

Imidacloprid. Imidacloprid is a chloronicotinyl insecticide that moves systemically within plants. It is effective against black turfgrass ataenius, white grubs, and weevils. Imidacloprid has relatively long persistence. Because initial effectiveness can be delayed for days after application, it may be best to apply it during the early part of the season (Fig. 4), when the grubs are in their earliest stages. In lawns that had damaging infestations the previous year, make treatments when adults are found in early to midsummer. If lawns are heavily infested with damaging levels of grubs later in the season, a more quick-acting, broad-spectrum insecticide may be necessary.

Pyrethrin. Pyrethrum, a botanical from flowers of certain chrysanthemums, contains pyrethrins, which are toxic to insects. Many pyrethrum products include the synergist piperonyl butoxide. Insects may only be temporarily paralyzed (knocked-down) and pests may recover from temporary effects of exposure to pyrethrum unless piperonyl butoxide is added.

SUGGESTED READING

Ali, A. D., and C. L. Elmore, eds. 1989. *Turfgrass Pests.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 4053.

Brandenburg, R. L., and M. G. Villani, eds. 1995. *Handbook of Turfgrass Pests.* Lanham, MD: Entomological Society of America.

Costa, H., R. Cowles, J. Hartin, K. Kido, and H. Kaya. 2000. Insects and Mites in *UC IPM Pest Management Guidelines: Turfgrass.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3365-T.

Flint, M. L., and S. H. Dreistadt. 1998. *Natural Enemies Handbook: The Illustrated Guide to Biological Pest Control*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3386.

Harivandi, M. A., and V. A. Gibeault. 1996. *Managing Lawns in Shade.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 7214.

Harivandi, M. A., and V. A. Gibeault. 1996. *Mowing Your Lawn and Grasscycling.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 8006.

Harivandi, M. A., and V. A. Gibeault. 1997. *Managing Lawns on Heavy Soils.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 7227.

Harivandi, M. A., W. B. Davis, V. A. Gibeault, M. J. Henry, J. A. Van Dam, L. Wu, and V. B. Younger. 1990. *Selecting the Best Turfgrass*. Oakland: Univ. Calif. Agric. Nat. Res. Leaflet 2589.

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ILLUSTRATIONS: Fig.1: Adult chafer from A. S. Packard. 1876. *Guide to the Study of Insects.* New York: Henry Holt; Sod webworm by R. M. Bohart. 1947. *Hilgardia* 17(8):275; other insect line art by Chittenden, Marlatt, or Webster from Sanderson, E. D. and C. F. Jackson. 1912. *Elementary Entomology.* Boston: Ginn.; Fig. 2: C. M. Dewees; Fig. 3: adapted from Gelenter, W. D. *Calif. Fairways,* Jan-Feb: pp. 6-8; Fig. 4: adapted from Ali, A. D., and C. L. Elmore, eds. 1989. *Turfgrass Pests.* Oakland: UC DANR Publ. 4053.
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To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

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LYME DISEASE IN CALIFORNIA

Lyme disease is a potentially debilitating and sometimes chronic infection transmitted to humans and other animals by certain ticks. The disease is caused by a spirochete, *Borrelia burgdorferi,* a corkscrew-shaped kind of bacterium. Of the 48 tick species found in California, the western black-legged tick, *Ixodes pacificus* (Fig. 1), is the only tick thought to be responsible for transmitting the spirochete to people. On average, only about 1 to 2% of the adult *I. pacificus* ticks and 2 to 15% of the nymphs are infected in California. In one woodland site in Mendocino County, however, 41% of the nymphs were found to contain Lyme disease spirochetes. A different but closely related tick species, *I. scapularis*, transmits spirochetes that cause Lyme disease in the northeastern and upper midwestern United States, but that tick does not occur in California.

First recognized in the mid-1970s in Lyme, Connecticut, Lyme disease has been reported in the United States, Canada, and in many European and Asian countries. The first Californian report of the disease appeared in 1978. State health authorities began monitoring this disease in 1983 and designated it a reportable disease in 1989. Since then, 1,938 cases have been reported in California through 1999 (Fig. 2). Of the 140 cases reported in 1999, the highest incidence per 100,000 people was in Trinity and Humboldt counties.

All ticks have three stages that feed on the blood of vertebrates: two immature stages (larva and nymph) and the adult stage. In California, only the nymph and the adult female are important in transmitting the Lyme disease spirochete to humans. People appear to be most at risk in spring until about midsummer, especially from April through July, when nymphal ticks are abundant. The nymphs (Fig. 1) live in leaf- and fir-needle litter areas in mixed hardwood forests. Unlike the adult ticks, nymphs do not climb on low vegetation while seeking a blood meal. The nymphs live within and beneath litter on the forest floor so any activity that places people in direct contact with shed leaves or fir-needles (e.g., gardening, picnicking, sitting, or lying down) may elevate the risk of contracting this disease. Nymphs are especially attracted to lizards but also feed on birds or small mammals. Once they attach to a host, the nymphs feed for about 3 to 5 days before they detach and drop off. They molt to the adult stage weeks or months later.

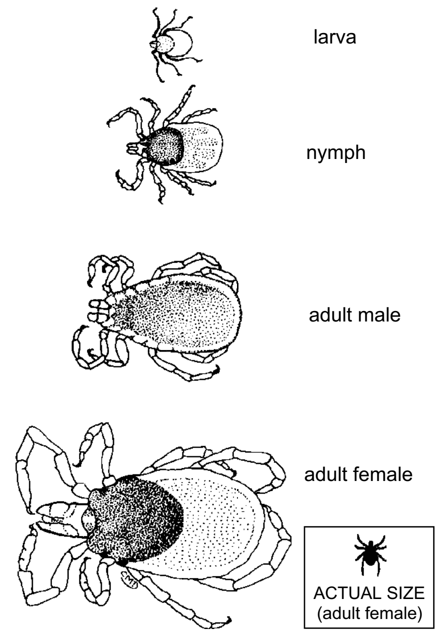

Figure 1. Western black-legged tick.

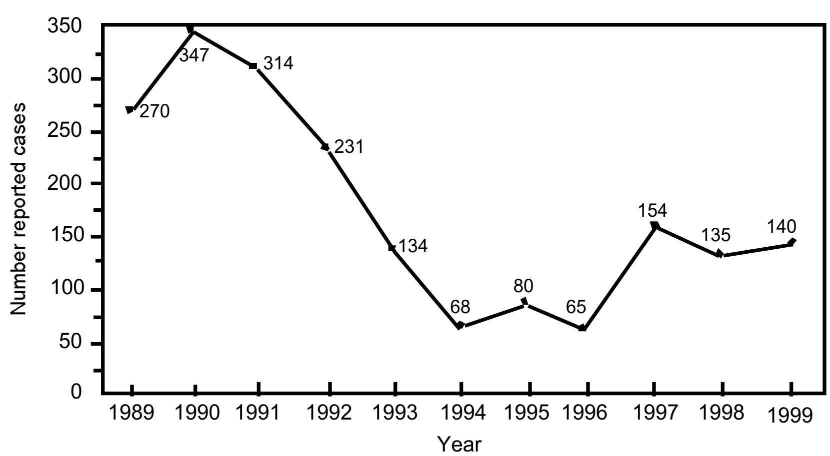

Figure 2. Lyme disease cases reported to the California Department of Health Services, 1989–1999.

Adult ticks are most active from late fall to early spring, but particularly in winter. They climb low vegetation such as grass or brush and lie in wait for hours or days while seeking their preferred medium- to large-sized hosts (e.g., rabbits, dogs, deer, and occasionally humans). It has been shown that about 85% of the adult ticks that infest the clothing of people walking through grassland do so between the ankle region and the knee. Therefore, when outdoors, individuals should frequently inspect their pant legs to detect and remove ticks before they have a chance to attach to skin. After attach-

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ing to a host, adult females ingest blood for about a week, engorging up to nearly four times their original body length. They then drop off the host and eventually deposit about 900 to 1,000 eggs in soil. Adult males rarely attach to people, feed little, and therefore are unimportant as carriers of disease organisms to humans or other animals.

People are more apt to be exposed to the adult ticks at certain times of day (morning/late afternoon versus midday); in fringe areas where two vegetational types merge (e.g., where grassland abuts with either brush or forest); and, in hilly areas, on low vegetation bordering the uphill instead of the downhill margins of hiking trails and on southern versus northern-facing slopes.

Besides the bacterium that causes Lyme disease, various ticks in California occasionally transmit at least eight other microbial agents of human disease such as those causing Colorado tick fever, Rocky Mountain spotted fever, relapsing fever, tularemia, or babesiosis. Mounting evidence suggests that the western black-legged tick is a primary transmitter of another recently recognized bacterial disease, ehrlichiosis, which is sometimes fatal. Thus, if a tick is tested for presence of Lyme disease spirochetes and is found to be uninfected, the possibility still exists that it could have been infected with another disease agent.

Commonly used antibiotics usually cure Lyme disease if administered within the first few weeks of infection. If treatment is delayed, however, the disease may progress to arthritic, neurologic, or cardiac problems weeks to months later. A vaccine to protect against Lyme disease was approved for human use in December 1998. However, the vaccine is registered for use only by individuals 15 to 70 years of age, it is about 76% effective after three doses, and it does not afford protection against other tick-borne diseases. In addition, the spirochetes are quite diverse in California, and research is underway to determine if more than one kind of spirochete can infect people. For these reasons, vaccinated individuals should continue to employ personal protective measures whenever they venture outdoors. If you spend much time outdoors in tick-infested areas, you can significantly reduce the risk of disease by taking a few simple precautions:

- Know how to recognize the western black-legged tick (Fig. 1). The nymph is about the size of a poppy seed (1/25 inch long) in its unfed state. It has four pairs of legs, a dark brownish black plate on its back, and a light-colored abdomen. The unfed female is about 1/8 inch long, has long mouthparts, brownish black legs, a dark brownish black plate that covers the anterior half of its back, and a reddish orange abdomen. Attached females may expand to 3/8 inch or longer while feeding. At 1/10 inch, adult males are smaller than females, somewhat oval shaped, and brownish black.

- Know where the ticks occur. The western black-legged tick is the most widely distributed of the 48 species of ticks known to occur in California. In fact, it has been recorded from 55 of the 58 counties. The adults are commonly encountered in grassy or brushy areas and along the margins of trails in parklands and wildlands, in semi-rural communities, and even in some suburban areas that support peri-domestic populations of deer and other wildlife, particularly in coastal counties and the foothills of the Sierra Nevada Range. The nymphs have been found exclusively in leaf/fir-needle habitats in deciduous, mixed hardwood forests.

- Dress appropriately. Wear full-length pants and a long-sleeved shirt in tick-infested areas. Ticks are easier to spot against light-colored clothing. Tuck your blouse or shirt into your pants, and tuck pant legs into boots or socks.

- As an added precaution, commercially available repellents or pesticides can be sprayed on skin or clothing. Follow the manufacturer's instructions carefully. Water or perspiration can wash repellents from your skin, so they may need to be reapplied after swimming or perspiring heavily.

- Inspect your clothing and exposed skin for ticks at least once an hour. Ticks may attach anywhere on the body, but on fully clothed persons they often attach to the scalp, behind an ear, or to an arm or leg. Pay particular attention to these areas when examining yourself or others.

- Check your pets after they have been outside because dogs and cats can carry ticks indoors. To protect your pets, use a commercially available tick collar or consult your veterinarian about some of the latest pesticides registered for controlling ticks on dogs or cats.

TICK REMOVAL

If you find an attached tick, remove it immediately. Prompt removal of infected ticks can prevent Lyme disease and other tick-borne diseases. Although research suggests that *I. pacificus* nymphs require 2 or more days of attachment to begin transmitting spirochetes to a host, other tick-borne agents (e.g., Colorado tick fever, Rocky Mountain spotted fever) may be transmitted within the first day.

Grasp the tick's mouthparts as close to the skin as possible with a pair of tweezers. If tweezers are unavailable, use your fingers, but protect them with tissue paper. Be careful not to squash a fed or partially fed tick because spirochetes released in fluids from a crushed tick may penetrate the unbroken skin or the bite wound.

Slowly and steadily pull the tick straight out. Remove any mouthparts that break off in the wound (consult a physician if necessary). The mouthparts may be contaminated with other bacteria that can cause painful secondary infections.

Do not jerk or twist the tick as you extract it. Do not apply alcohol, fingernail polish, heat from a lit match, or petroleum jelly to the tick; these methods are completely ineffective. Applying heat may actually propel disease

Figure 3. Erythema migrans, the skin rash common in the early stage of Lyme disease, is shown here developing in the knee area.

agents into the bite wound by inducing the tick to regurgitate or secrete saliva.

Clean the wound with soap and water. Apply a mild antiseptic such as povidone-iodine, if available.

Whenever an attached tick is removed from a person, it should be saved for later identification in case the person experiences an illness within a month of the bite. Most people who contract Lyme disease or other tick-borne diseases usually become ill within 1 to 2 weeks after being bitten. Acarologists (scientists who study ticks and mites) and entomologists employed by governmental agencies (e.g., state and local health departments, mosquito and vector control districts) or universities may be available to assist with tick identifications.

DISEASE MANIFESTATIONS

For light-skinned persons, Lyme disease begins in up to 60 to 80% of patients as a slowly expanding, reddish rash known as erythema migrans (Fig. 3) 3 to 32 days after the bite of an infectious tick. The rash, if present, may be obscure on dark-skinned patients. However, 50% or more of Lyme disease patients may not recall having been bitten by a tick. Attached nymphal ticks are particularly prone to be overlooked because of their smaller size and reduced feeding time as compared with adult female ticks. The rash typically begins at the wound site and may expand slowly to several inches in diameter before disappearing within 3 to 4 weeks. Antibiotic treatment hastens disappearance of the rash, which may vanish in about a week. Many victims experience fatigue, headache, fever, chills, and other flulike symptoms during the initial stage of illness.

Days to weeks later, a variety of other clinical manifestations may occur singly or in combination. These can involve the skin (secondary rashes), musculoskeletal system (migratory pain in joints, tendons, muscles, or bones), neurologic system (headache, facial palsy, memory loss), lymphatic system, heart, eyes, liver, respiratory system, or kidneys.

Finally, late (persistent) infection normally begins a year or more after onset of the disease, and may involve arthritic, neurologic or further skin manifestations, profound fatigue, or inflammation of the cornea in the eyes.

Dogs, horses, and other domesticated animals susceptible to Lyme disease may develop arthritis or lameness, lethargy, loss of appetite, disease of the lymph nodes, or other conditions after being infected. If you suspect that your pets or livestock have Lyme disease, or if you wish to consider protecting your dog(s) with one of the commercially available Lyme disease vaccines, consult a veterinarian.

REFERENCES

Furman, D. P., and E. C. Loomis. 1984. The ticks of California (Acari: Ixodida). *Bull. Calif. Insect Surv.* 25:1-239.

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The information contained in this ***Pest Note*** is based on many years of research by the writer and his various co-workers including graduate students, postdoctoral researchers, technicians and colleagues at other institutions. Though too numerous to single out individually, sincere thanks are extended to all of them for their invaluable contributions. Also, it represents an updated and expanded version of an earlier publication entitled ÒProtection from Lyme disease in California,Ó which was published as a 2-sided sheet in 1990 (No. 7189, Cooperative Extension, University of California, Division of Agriculture and Natural Resources). The principal source of the general information about the clinical manifestations of Lyme disease was a review written by Allen C. Steere (1989. ***N. Engl. J. Med.*** 321:586-596). Robert A. Murray and Vicki L. Kramer of the California Department of Health Services kindly provided information about the incidence and number of cases of Lyme disease reported in the state. Lars TŠlleklint-Eisen, University of California at Berkeley, provided constructive suggestions on the initial draft. Finally, the research upon which most of the foregoing information is based was funded in part by grants from the National Institutes of Health, cooperative agreements from the Centers for Disease Control and Prevention, and state or federal funds administered through the Agricultural Experiment Station, University of California, to the writer.

PSYLLIDS

Integrated Pest Management for Landscape Professionals and Home Gardeners

Psyllids resemble miniature cicadas and are sometimes called jumping plantlice. Over 100 species occur on both native and introduced landscape plants in the United States, but each kind of psyllid feeds on only one plant species or closely related groups of plants. Most psyllids native to the United States are relatively uncommon and rarely become pests. Most pest psyllids in California are exotic species inadvertently introduced from other countries.

IDENTIFICATION AND LIFE CYCLE

Adult females lay eggs that hatch and develop through about five wingless, immature nymphal stages before becoming winged adults. Most pest psyllids in California occur on evergreen plants in mild-climate areas where all life stages may be found year-round. Psyllids become abundant in spring when temperatures warm and host plants produce new growth flushes. One psyllid generation requires only a few weeks during warm weather to complete development from egg to egg. High temperatures may reduce populations of some species.

Adults hold their wings rooflike over their bodies and at maturity are 1/10 to 1/5 inch long (Fig. 1). Psyllids are related to aphids but have strong jumping legs and shorter antennae. Nymphs are flattened and less active than adults. Don't confuse psyllid adults with similar looking but harmless psocids, which feed on fungi, including sooty mold growing on psyllid honeydew. Mature psyllids commonly jump when disturbed, while psocids run or fly away. Psocids have a more narrow "neck" or separation between the head and the thorax and chewing mouthparts, as compared to psyllids, which have tubular, sucking mouthparts. Because several hundred species of psyllids occur just on acacia and eucalyptus in the Australian region, new psyllid species are likely to be introduced into California. Take psyllids you are unable to identify to a Cooperative Extension or agricultural agency expert.

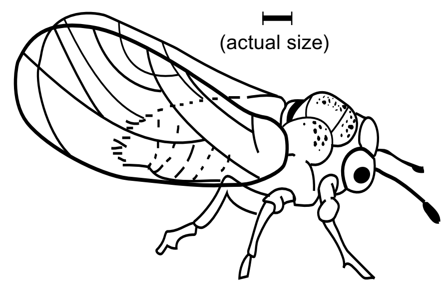

Figure 1. Adult psyllid.

Acacia Psyllid. Acacia psyllid occurs on leaves, terminal shoots, and flower buds of many *Acacia* and *Albizia* species. Adults are green to brownish but often appear darker during cooler weather. The tiny, golden eggs and the orange to green, flattened nymphs are most abundant on the surface of new growth. Up to about eight generations a year are reported in California with the greatest densities in coastal urban regions.

Bluegum Psyllid. At least six species of psyllid occur on eucalyptus in California. The bluegum psyllid infests eucalyptus species that have waxy blue juvenile foliage, such as blue gum (*Eucalyptus globulus*). However, significant damage has largely been limited to foliage of silver-leaved mountain gum, also called baby blue gum (*Eucalyptus pulverulenta*) grown commercially for floral arrangements. Bluegum psyllid adults are grayish. When mating tail-to-tail, pairs may look like a tiny grayish moth unless examined more closely. The pale yellow to cream-colored eggs are laid in crevices between buds and young leaf petioles or openly on young leaves. Young nymphs are orangish, becoming mostly grayish with olive green markings as they mature. Colonies of bluegum psyllids are covered with whitish wax. The insect can have four or more generations per year.

Eugenia Psyllid. Eugenia psyllid occurs primarily on Australian brush cherry or eugenia (*Syzygium paniculatum*). It has also been observed on juvenile foliage of New Zealand Christmas tree (*Metrosideros excelsus*). Adults are mostly dark brown with a white band around the abdomen. Their tiny golden eggs are laid primarily along the edges of young leaves, causing infested leaf margins to glisten in the sun. Nymphs are yellowish with orange-red eyes. Recently hatched first-instar nymphs (called crawlers) settle on new growth and each forms a feeding pit. Settled nymphs resemble a soft scale insect and appear flat when viewed from the lower leaf surface. The upper surface of infested foliage reddens and distorts above these pits. Eugenia psyllid has about three to about five generations a year, depending on temperature and host plant suitability. High populations in California are limited to counties near the coast.

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Peppertree Psyllid. Peppertree psyllid feeds only on the California pepper tree (*Schinus molle*), a plant that despite its common name is native to South America and was introduced into California by Spanish settlers. Adult peppertree psyllids are greenish or tan and somewhat pear shaped. The tiny, translucent, white eggs are deposited on the tender growth of pepper trees. The orangish nymphs feed on young expanding plant growth and the plant forms a pit around where each nymph settled. Infested leaves may become somewhat distorted or crinkled.

Redgum Lerp Psyllid. Redgum lerp psyllid produces conical wax and honeydew coverings called lerps. It severely infests several species of eucalyptus, especially river red gum (*Eucalyptus camaldulensis*). Insecticides have been of limited effectiveness and parasites (*Psyllaephagus bliteus*) are being introduced against this pest, which is discussed in *Pest Notes: Eucalyptus Redgum Lerp Psyllid* (see "References").

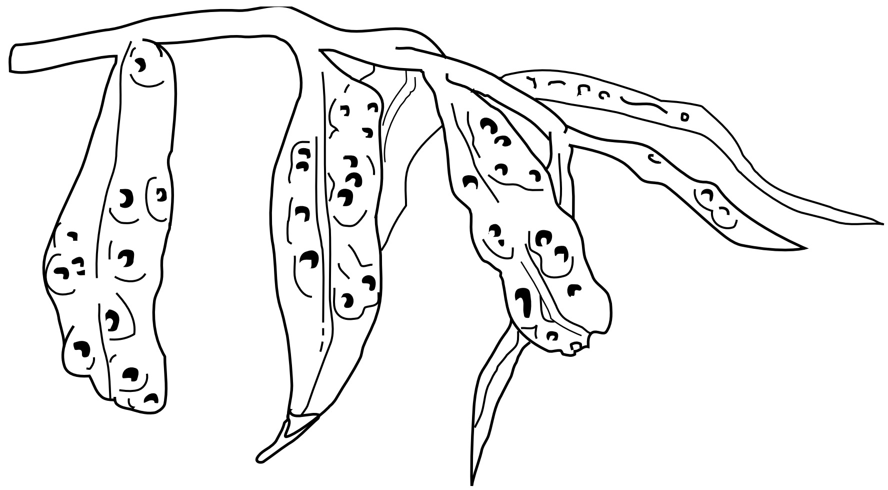

Figure 2. Feeding by psyllid nymphs pits and distorts California pepper tree foliage.

DAMAGE

Psyllids suck plant juices. Some secrete a white wax and all produce honeydew, sometimes in pelletized or crystallized form, on which blackish sooty mold grows. High psyllid populations reduce plant growth or cause terminals to distort, discolor, or die back. High populations of certain species, such as eugenia psyllid, can cause defoliation. A few species cause galls on leaves or buds, for example when psyllid feeding causes the plant to form a pit around where each nymph settles (Fig. 2). Early damage typically occurs on young foliage where most eggs are laid.

Many native California trees and shrubs such as lemonade berry and sugar bush (*Rhus* species), manzanita (*Arctostaphylos*), and willow (*Salix*) that are planted as ornamentals can host native psyllid species. These are hardly ever problems and even if psyllids are abundant, most plants tolerate extensive psyllid feeding. Several gall-making *Pachypsylla* species infesting hackberry (*Celtis*) and the boxwood psyllid (*Psylla buxi*), which occurs only on boxwood (*Buxus*) and causes terminal leaves to become cupped, are pests primarily in the eastern United States. Pear psylla (*Cacopsylla pyricola*), which infests pear fruit trees throughout the United States, is one of the few psyllids that is an agricultural pest (see *Integrated Pest Management for Apples and Pears* or *UC IPM Pest Management Guidelines: Pear*, listed in "References"). In the home landscape, however, it is introduced species of psyllids that are mainly a problem on introduced species of plants.

MANAGEMENT

Most native species of psyllids require no management; even when populations are abundant, plants can tolerate substantial feeding and psyllid populations will decline naturally. The bluegum psyllid, and in many situations the peppertree psyllid, are under effective biological control and require no management except to conserve natural enemies. Parasites are being introduced for the redgum lerp psyllid, but this species and psyllids that infest acacia and eugenia may warrant a more comprehensive management program than just reliance on biological control. If control is necessary, use an integrated program incorporating appropriate plant care, conservation of natural enemies, and where feasible the use of least-toxic insecticides. No treatment restores damaged foliage; it remains distorted until trimmed or replaced by new growth.

Because psyllid damage is primarily aesthetic, tolerance varies among people and with the species and location of plants. Determine the level of damage you are willing to tolerate. Monitor adult psyllids before damage becomes evident and record the numbers of adults present on a weekly basis. During subsequent seasons take control action, if necessary, when populations or damage approach the levels that you previously found to be intolerable. Keep in mind that foliar damage is primarily caused by nymphs, but sprays are aimed at killing eggs or newly hatched nymphs before the damage occurs, which is why the adults are monitored. Therefore, a decision to spray should be based on the numbers of adults infesting the plants several weeks before damage from nymphs becomes intolerable.

Monitoring

Yellow sticky traps are the best way to monitor psyllids infesting eucalyptus and eugenia. Yellow sticky traps are available from most well-stocked garden supply stores or they can be homemade by painting clear plastic disks, such as 4-inch-diameter cottage cheese container lids, with fluorescent or bright yellow paint (e.g., Rustoleum Yellow No. 659). Coat the bright yellow surface of homemade traps with a thin film of STP motor oil additive, which is viscous enough to snare adult psyllids but generally allows larger, stronger insects to escape. Other coatings include clear polybutene sticky material (e.g., Stikem, Tanglefoot) or an adhesive that can be made from one part petroleum jelly (e.g., Vaseline) or mineral oil mixed with one part household detergent. In hot weather, however, the adhesive made from petroleum jelly may drip off the traps unless it is applied thinly. As an alternative to directly coating the yellow surface, place sticky material on separate removable layers of clear plastic sandwiched over the yellow surface.

Adult psyllids and psyllid parasites are attracted to the yellow color and become stuck to the surface. (Consult the online version of this publication at www.ipm.ucdavis.edu for color photographs of the parasites.) Inspect the traps once each week and count (or estimate) and record the number of adult psyllids and their parasites. Following each count, remove the trapped insects from the trap by scrapping them off. Periodic cleaning or replacement of traps is essential to maintain the sticky surface.

Adult psyllids can also be monitored by shaking or tapping plants over a collecting surface to knock them onto the collecting surface where they can be easily seen and counted. The collecting surface can be a special beating tray, sheet, or a clipboard with a white sheet of paper that is held beneath the beaten branch. Shake the plant or sharply tap foliage two or three times and count and record the number of live psyllid adults and their parasites that you see on the collection surface. Do this on two or three different portions of two or more representative plants. Sample about once each week during the season when psyllid adults or new growth are expected. Shaking or beat monitoring may be best for acacia psyllid because it also monitors important psyllid predators (described below).

In addition to the adult psyllids present, keep a close watch on the number of new growing tips on a plant and on their general rate of growth. You may discover an annual cycle to psyllid abundance; population increases are typically associated with the availability of tender new growth. Conversely, the presence of large numbers of psyllid adults may be no cause for concern when a growth flush is nearing its end; the same number of adults observed when a plant is weak or growing poorly might warrant closer attention.

Cultural Control

Avoid excess irrigation and do not fertilize established woody plants unless foliage appearance or plant growth is unsatisfactory because of a confirmed nutrient deficiency. Most nutrient deficiency symptoms are caused by poor root health (such as infection by fungal pathogens) or improper soil conditions (such as inappropriate soil pH, inadequate drainage, and excess irrigation). These adverse root conditions cause unhealthy looking foliage even when nutrient levels in soils are sufficient for plants; adding fertilizer will not remedy these problems. Irrigating appropriately and avoiding fertilization discourages the excessive succulent foliage that promotes increased populations of phloem-sucking insects such as psyllids.

Except as discussed below for eugenia psyllid, minimize shearing or pruning of terminals. Shearing to provide a smooth, dense canopy surface for ornamental purposes (such as formal hedging or topiary pruning) stimulates new growth, which is preferred by psyllids.

Avoid planting susceptible species and consider replacing problem-prone plants. Some people consider extensive planting of eucalyptus to be undesirable and recommend alternative plants (such as California natives), especially since the recent introduction of several eucalyptus pests (for example, see *Pest Notes* on eucalyptus longhorned borers and redgum lerp psyllid, listed in "References"). Consider planting acacia species that are rarely or lightly infested with acacia psyllid (Table 1). Australian willow myrtle or peppermint tree (*Agonis flexuosa*), desert willow (*Pittosporum phillyraeoides*), and Australian willow (*Geijera parviflora*) are relatively drought-tolerant and have a weeping appearance that resembles pepper tree but they are not affected by the peppertree psyllid.

Biological Control

Natural enemies, including lady beetles, lacewing larvae, small preda-

Table 1. Species of Acacia and Albizia that are Lightly or Rarely Infested by Acacia Psyllid.

***Acacia* species**
adansonii, albida, aneura, arabica, armata, aroma, aspera, baileyana[1], *bonariensis, brachystachya, caffra, calamifolia, cambagii, congesta, crassiuscula, cyanophylla, dealbata, deanii, dentifera, diffusa, drummondii, flexifolia, giraffae, horrida, howittii, karroo, kempeana, latifolia, linearis, lineata, linophylla, nealii, nerifolia, oswaldii, oxycedrus, pennata, plumosa, podalyriifolia, salicina, spirocarpa, verticillata, vestita, visco, woodii*

***Albizia* species**
fastigiata, odoratissima, polyphylla

[1] Susceptible to the baileyana psyllid, *Acizzia acaciaebaileyanae*.
Sources: Koehler, C. 1973. *Albizia Psyllid on Acacia and Albizia.* Hayward, CA: Univ. Calf. Coop. Exten. Alameda Co.; Koehler, C. S., W. S. Moore, and B. Coate. 1983. Resistance of acacia to acacia psyllid, *Psylla uncatoides. J. Environ. Hort.* 1: 65-67.

ceous bugs, and parasitic wasps, which attack only certain psyllids, provide at least partial control of all the psyllids discussed here. Conserve psyllid natural enemies by using appropriate cultural practices and only low toxicity, short-persistence pesticides or, whenever possible, inject insecticides instead of spraying if direct control action is needed. The introduced species of natural enemies now occur naturally throughout California; they are not available commercially for purchase and release.

Acacia Psyllid. Acacia psyllid populations have been greatly reduced by a 1⁄16-inch-long black lady beetle (*Diomus pumilio*) introduced from Australia, a 1⁄7-inch-long purplish pirate bug (*Anthocoris nemoralis*) from Europe, and several native predators, including brown lacewings (*Hemerobius* species). Acacia psyllid populations in the San Francisco Bay area typically decline dramatically during June and July after predators become abundant. However, this biological control may not be effective until some lag time after weather warms in spring and psyllid populations have increased; in northern California this is typically during April and May. Tolerate psyllids for several weeks and conserve natural enemies until predators provide control. Alternatively, temporarily reduce high populations by thoroughly covering new outer and upper canopy acacia growth with low toxicity insecticides such as oil or soap as discussed below. To entirely eliminate the problem, consider replacing susceptible plants with other appropriate species, such as acacias or albizias, which are not preferred by acacia psyllid (Table 1).

Bluegum Psyllid. The bluegum psyllid is effectively controlled by a tiny parasitic wasp (*Psyllaephagus pilosus*) that attacks only bluegum psyllid. Most bluegum psyllids will develop into puffy, brownish mummies, each containing a parasite that killed the psyllid. When bluegum psyllids are observed, avoid spraying pesticides that can disrupt biological control. No control is needed other than conserving parasites.

Eugenia Psyllid. Eugenia psyllid is partially controlled by an introduced *Tamarixia* species of parasitic wasps. However, especially in cooler areas near the California coast, parasite populations often do not increase quickly enough in spring to provide satisfactory control. Regular shearing of new growth provides substantial control by removing psyllid eggs and nymphs. Well-timed pruning in combination with parasite conservation can be especially effective in managing psyllids infesting eugenia topiary plantings.

Where pruning or other control methods are planned, inspect plants regularly for new growth, beginning in spring. Also consider regular monitoring for adult psyllids, especially when managing many eugenias. Prune terminals after maximum spring growth appears or about 3 weeks after the first peak in adult psyllid density, which is determined by using sticky traps and counting and recording the number of adult psyllids on a weekly basis as discussed in “Monitoring.” Leave eugenia clippings as mulch near the shrubs for at least 3 weeks to allow parasites within psyllid nymphs to complete their development and emerge (Fig. 3). Eugenia psyllid eggs and nymphs on the cut foliage will die. Consider shearing eugenia tips at about 3-week intervals (and leaving clippings on-site) throughout the period of new plant growth or as long as adult psyllids are abundant. In addition to providing direct control, shearing terminals is the only way of eliminating damaged foliage (aside from waiting for old leaves to drop). No pesticide or other treatment will restore pitted foliage to a healthy appearance.

Peppertree Psyllid. Peppertree psyllids are partially controlled, often satisfactorily, by an introduced *Tamarixia* species of parasitic wasp that is different from the one that was introduced for eugenia psyllid. No additional control is required in many situations. Moderate psyllid damage is often tolerable in part because peppertree psyllid produces relatively little honeydew. The pepper tree also has finely divided leaves, and foliage distortion by psyllids can easily be overlooked, especially on branches above eye-level. Improving soil conditions and cultural practices are usually much more important methods of improving pepper tree health than taking control measures for psyllids. Pepper trees are adapted to well-drained, sandy soil, and summer drought. Planting trees in heavy clay soils or in summer-watered landscapes, such as lawns, promotes root disease and causes trees to decline and die. Improve soil drainage and remove irrigated landscape from near

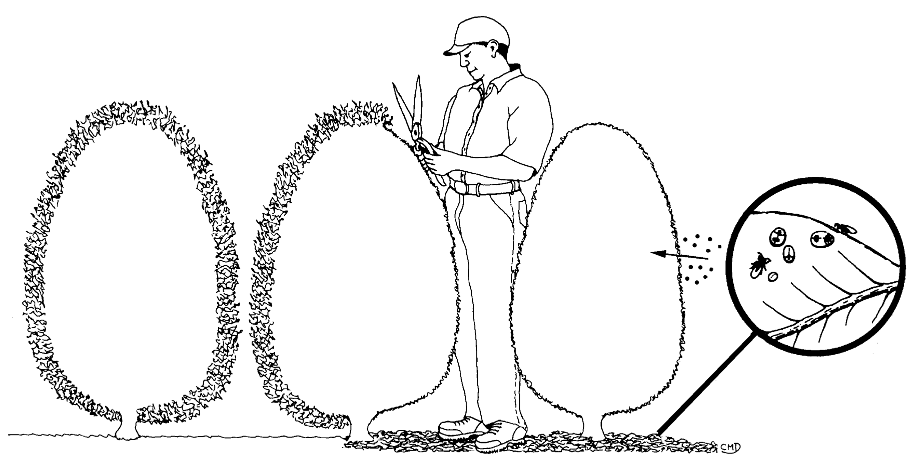

Figure 3. Leave clippings from eugenia bushes as mulch on the ground for at least 3 weeks to allow parasites to complete their development and return to the shrubs where they lay eggs that parasitize other psyllid nymphs.

trunks to improve pepper tree health and increase pepper trees' ability to tolerate psyllids.

Chemical Control

Because beneficials often do not become abundant until after psyllids are common and weather has warmed, supplemental control may be desired in certain situations. However, psyllids are difficult to control effectively with insecticides because they reproduce year-round in much of California and can infest large plants or those with dense canopies, which prevents good spray coverage. Limit use of insecticides to situations where psyllids and their damage cannot be tolerated. In the case of redgum lerp psyllid, pesticides believed to be the most effective against this pest (systemic insecticides) can be of limited and variable effectiveness, especially if trees are stressed or already heavily damaged.

Azadirachtin (Azatin, Neemazad), neem oil, insecticidal soap (potassium salts of fatty acids), and horticultural oil (an insecticide labeled narrow range, superior, or supreme oil) can provide temporary control of psyllids that are directly contacted by the spray. Infested new growth must be thoroughly covered with the insecticide spray. The low toxicity and short-persistence of these "organically acceptable" materials does not kill natural enemies that migrate in after the spray has dried, so application of these materials early in the season before natural enemies buildup on (and migrate from) nearby unsprayed plants is compatible with later-season biological control. However, an additional treatment may be necessary within several weeks if psyllid populations rebound and the plants produce a new growth flush.

Time an insecticide application to kill eggs and young nymphs before damage or psyllids become abundant. Monitor when susceptible new growth or adult psyllids or both become abundant as discussed in "Monitoring." Treat soon after a sharp increase in adult numbers is observed on sticky traps or in beat samples, or when significant numbers of eggs are observed on leaves and shoots. Continue monitoring after treatment. If natural enemies as well as psyllids become abundant, delay reapplication and monitor again later to determine if populations have declined and spraying can be avoided.

Systemic insecticides are the most practical, effective materials for controlling psyllids that infest large trees. Some are available only to licensed pesticide applicators, and generally only professionals have the equipment and experience to apply them effectively to large trees. Systemic insecticides for psyllid control include the organophosphate acephate (Orthene) and the chloronicotinyl insecticide imidacloprid (Marathon and Merit for licensed applicators and Bayer Advanced Garden Tree and Shrub Insect Control Concentrate for home gardeners). Imidacloprid has the advantage of being formulated into a product that can be applied to soil, thus avoiding the plant injury that occurs when trunks are injected or implanted with insecticide. Unlike spraying insecticides onto the plant foliage, soil applications avoid killing natural enemies. The microbial abamectin (Avid) can be injected into trees or sprayed on foliage by licensed applicators. Abamectin is effective against pear psylla, but its effectiveness against psyllid species that infest ornamentals is uncertain.

Carbamates (e.g., carbaryl), nonsystemic organophosphates (malathion), and pyrethroids (fluvalinate, permethrin) also can be applied, but these insecticides are not recommended. They generally are not as effective in controlling psyllids as the systemic materials discussed above, and spraying them kills many important natural enemies.

REFERENCES

Dahlsten, D. L. 2000. Psyllid biological control Web site (http://nature.berkeley.edu/biocon/dahlsten/dahlsten.htm)

Dahlsten, D. L., D. L. Rowney, W. A. Copper, R. L. Tassan, W. E. Chaney, K. L. Robb, S. Tjosvold, M. Bianchi. and P. Lane. 1998. Parasitoid wasp controls blue gum psyllid. *Calif. Agric.* 52(1):31-34.

Dahlsten, D. L., D. M. Kent, D. L. Rowney, W. A. Copper, T. E. Young, and R. L. Tassan. 1995. Parasitoid shows potential for biocontrol of eugenia psyllid. *Calif. Agric.* 49(4):36-40.

Dreistadt, S. H., J. K. Clark, and M. L. Flint. *Pests of Landscape Trees and Shrubs: An Integrated Pest Management Guide*. 1994. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3359.

Dreistadt, S. H., R. W. Garrison, and R. Gill. Aug 1999. *Pest Notes: Eucalyptus Redgum Lerp Psyllid*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 7460. Also available online at www.ipm.ucdavis.edu

Dreistadt, S. H., and K. S. Hagen. 1994. Classical biological control of the acacia psyllid, *Acizzia uncatoides* (Homoptera: Psyllidae), and predator-prey-plant interactions in the San Francisco Bay area. *Biological Control* 4: 319-327.

Elkins, R. B., R. Van Steenwyk, L. Varela, and C. Pickel. Feb 2001. Insects and Mites from *UC IPM Pest Management Guidelines: Pear*. Oakland: Univ. Calif., Agric. Nat. Res. Publ. 3339. Also available online at www.ipm.ucdavis.edu

Paine. T. D., J. G. Millar, and S. H. Dreistadt. Jan 2000. *Pest Notes: Eucalyptus Longhored Borers.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 7425. Also available online at www.ipm.ucdavis.edu

UC Statewide IPM Project. 1999. *Integrated Pest Management for Apples and Pears*, 2nd ed. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3340.

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WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

RED IMPORTED FIRE ANT

Integrated Pest Management in and around the Home

Although the red imported fire ant (*Solenopsis invicta*) is common in 12 southern states, it is new to California and has recently been found infesting numerous residential and commercial areas in Orange, Los Angeles, Riverside, San Bernardino, and to a lesser extent, San Diego counties. The spread of these ants has largely been a result of the movement of infested soil to uninfested areas.

IDENTIFICATION

Red imported fire ant workers (Fig. 1) are variable in size (1⁄16 to 1⁄5 inch long) and dark reddish brown. Unlike our native southern fire ant (*Solenopsis xyloni*) and harvester ant (*Pogonomyrmex californicus*), the red imported fire ant can quickly produce many nests and colonize a yard. Harvester ant workers are all the same size (1⁄5 inch long) and are red in color. Many people refer to these as "red ants." The most common ant around homes in California is the Argentine ant, *Linepithema humile*, a small grayish black ant that is uniform in size (1⁄10 inch long) and is seen moving along in long trails. While there are several physical characteristics that distinguish red imported fire ants from other common ant species found in California, one way to recognize this pest is to observe its aggressive behavior when its nest or food source is disturbed or to experience its painful bite and sting.

In areas that are not disturbed, red imported fire ants typically make dome-shaped mounds (Fig. 2) that are about 18 inches across and about 8 to 12 inches tall. They resemble large gopher mounds or look like crumbly earth with small holes; these mounds readily distinguish red imported fire ant colonies from other California ant colonies. Nests of the native southern fire ant, for instance, are usually irregular and consist of scattered soil with multiple obscure entrances. Unlike the other ant species mentioned, red imported fire ants tend to build nests in open, sunlit, grassy areas that are typically irrigated. They will readily run up any object that touches their mound, whereas the other species are much less aggressive. Because red imported fire ants often build their nests in turfgrass areas in California, frequently the mounds have been mowed and are nearly flat, appearing as soft, loose dirt that obscures the grass and looks like a bald spot in the turf.

In some instances red imported fire ants do not build mounds but nest in places such as rotten logs, walls of buildings, or under sidewalks.

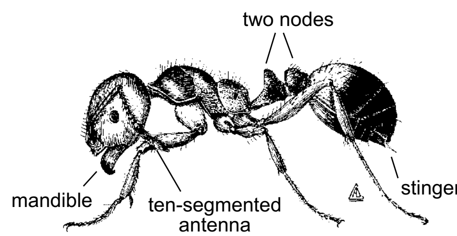

Figure 1. Adult red imported fire ant worker.

LIFE CYCLE

The fire ant life cycle, like that of other social Hymenoptera (ants, bees, and wasps), consists of four main stages: egg, larva, pupa, and adult (Fig. 3). The egg, larval, and pupal stages occur

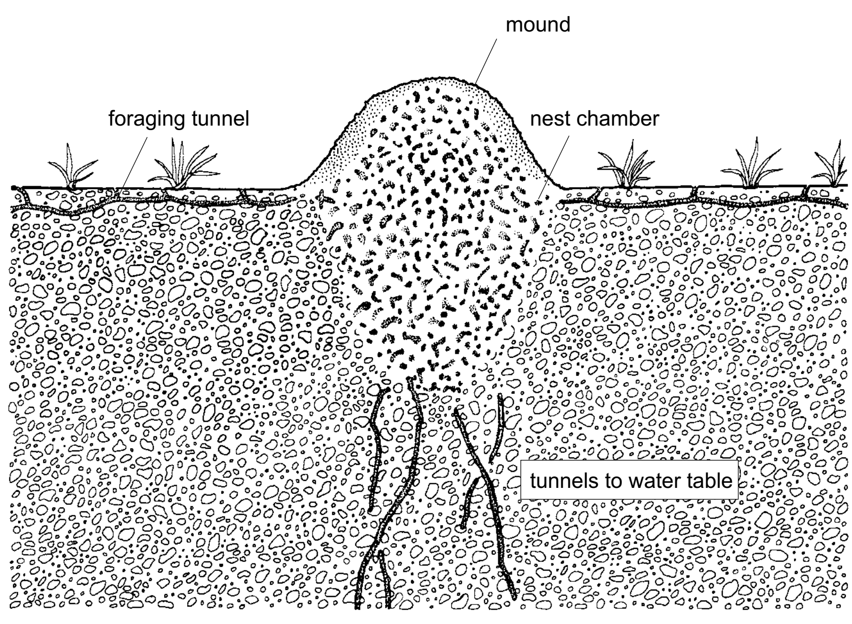

Figure 2. Cross section of a red imported fire ant mound.

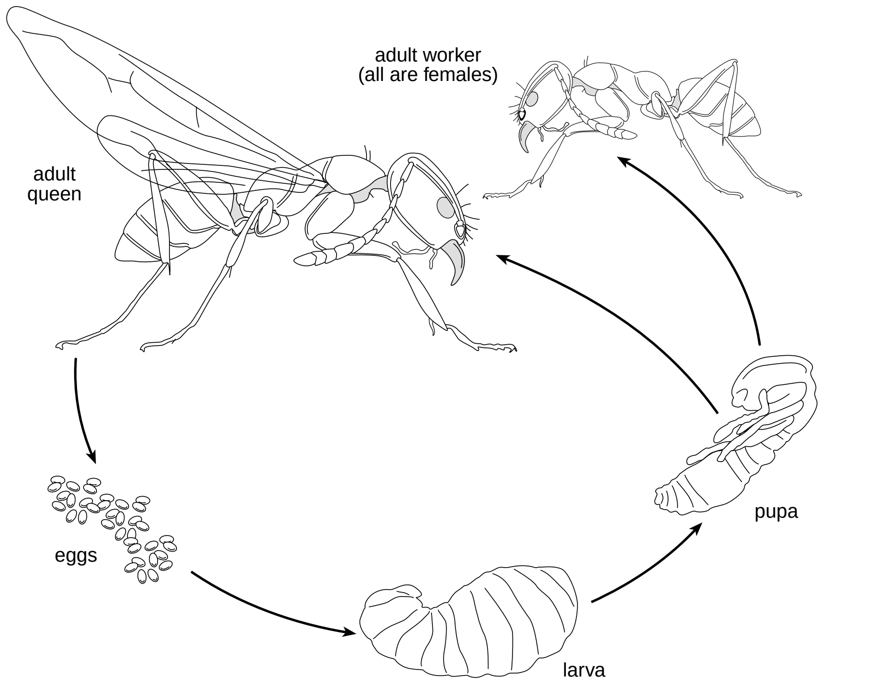

Figure 3. Life cycle of the ant.

within the underground nest and are only seen when nests are disturbed or when they are being carried to a different location by workers. The eggs are almost too small to be seen with the unaided eye. They hatch into the grublike larvae that are fed by the workers. There are four larval instars (stages); the fourth larval instar is particularly important because it is the only stage that can ingest solid food. Once the larvae finish their growth, they molt into pupae, which look like adults except that their legs and antennae are held tightly against the body. These pupae are initially white, but begin to turn darker as they mature. In the final molt the pupa becomes an adult.

Most larvae develop into sterile worker ants, all of them female and wingless. However, some larvae in the colony receive extra food during their development and become much larger than the larvae destined to become workers. These larger larvae will develop into reproductives. Large numbers of reproductives are normally produced once a year in the spring in preparation for a mating flight, although flights can occur more than once a year if conditions are favorable. The female reproductives are future queens and have wings. Male larvae develop into winged adult males that are black in color and have a smaller head and larger thorax than female reproductives. During a mating flight, the winged males and females fly and mate in midair before falling back to the ground. Males die shortly afterward; the mated queens remove their wings and dig a small hole in the soil and seal themselves inside. In the nest, the queens begin to lay eggs that develop into small worker ants in a month or two.

Some fire ant colonies have only one queen per nest and are called “monogyne” colonies. Others can have many queens and are called “polygyne” colonies. The polygyne colony may be more difficult to control because all the queens must be killed to prevent the colony from surviving. Polygyne colonies frequently expand by “budding"; i.e., some of the queens and workers start a new mound nearby. This process accounts for much higher mound densities for polygyne colonies than for monogyne colonies, sometimes approaching 1,000 mounds per acre.

DAMAGE

The red imported fire ant’s sting is a serious concern to people and their pets. Venom injected into the skin causes a burning sensation (hence the name “fire ant”). Both southern fire ants and red imported fire ants become very agitated when their nests are disturbed, but red imported fire ants are much more aggressive and can quickly climb onto the object or person causing the disturbance and begin stinging. A single red imported fire ant can bite and sting its victim repeatedly (Fig. 4). Symptoms start as a burning and itching sensation followed by the formation of a white pustule, which takes several weeks to disappear. The pustules can become infected if not kept clean and may leave permanent scarring.

A small percentage of the human population is allergic to these stings. If a person experiences chest pains, nausea, dizziness, or shock, they should seek emergency medical assistance immediately after a stinging incident. Avoid medical emergencies by teaching children and visitors about fire ants.

Fire ants feed on almost any plant or animal material, including other insects, ticks, ground-nesting animals, young trees, seedlings, plant buds,

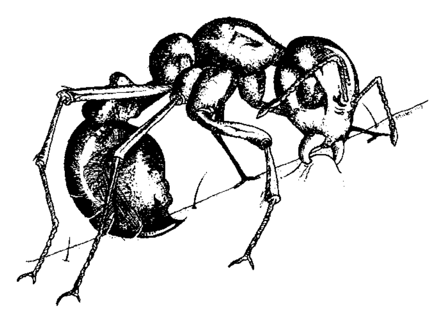

Figure 4. A red imported fire ant attack involves both a bite and a sting.

developing fruits, and seeds. In addition to their stings, the red imported fire ant causes problems by building its nests around trees, yard plants, pipes, and in the walls of structures. Colony-building can damage plants, lawns, and outdoor electrical fixtures.

MANAGEMENT

Because fire ants can sting en masse, most people will want to keep them off their property. This contrasts with other common ant species, such as the Argentine ant, where the primary goal is to keep them out of homes. For management of household ants, see *Pest Notes: Ants*, listed in "References."

California currently has a program aimed at eradicating the red imported fire ant within the state. Therefore, homeowners should not attempt their own control measures. Any suspected infestation should be reported using the statewide toll free number that has been set up by the California Department of Food and Agriculture for this purpose (1-888-4fireant). There is also an informative web site, www.fireant.ca.gov. Once contacted, state personnel will determine if the ants are red imported fire ants, and if so, will apply approved treatments free of cost or recommend a course of action.

REFERENCES

Drees, B. M., C. L. Barr, D. R. Shanklin, D. K. Pollet, K. Flanders, and B. Sparks. 1999. *Managing Red Imported Fire Ants in Agriculture*. College Station, TX: Texas Agricultural Extension Service.

Drees, B. M., C. L. Barr, S. B. Vinson, R. E. Gold, M. E. Merchant, and D. Kostroun. 1996. *Managing Red Imported Fire Ants in Urban Areas*. College Station, TX: Texas Agricultural Extension Service.

UC Statewide IPM Project. Nov 2000. *Pest Notes: Ants.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 7411. Also available at www.ipm.ucdavis.edu

Vinson, S. B. 1997. Invasion of the red imported fire ant (Hymenoptera: Formicidae): Spread, biology, and impact. *American Entomologist* 43(1):2339

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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YELLOWJACKETS AND OTHER SOCIAL WASPS

Integrated Pest Management in and around the Home

Only a few of the very large number of wasp species in California live a social life; these species are referred to as social wasps. Some social wasps are predators for most or all of the year and provide a great benefit by killing large numbers of plant-feeding insects and nuisance flies; others are exclusively scavengers. Wasps become a problem only when they threaten to sting humans. One of the most troublesome of the social wasps is the yellowjacket. Yellowjackets, especially ground- and cavity-nesting ones such as the western yellowjacket (Fig. 1), tend to defend their nests vigorously when disturbed. Defensive behavior increases as the season progresses and colony populations become larger while food becomes scarcer. In fall, foraging yellowjackets are primarily scavengers and they start to show up at picnics, barbecues, around garbage cans, at dishes of dog or cat food placed outside, and where ripe or overripe fruit are accessible. At certain times and places, the number of scavenger wasps can be quite large.

IDENTIFICATION AND LIFE CYCLE

In western states there are two distinct types of social wasps: yellowjackets and paper wasps. Yellowjackets are by far the most troublesome group. Paper wasps are much less defensive and rarely sting humans. They tend to shy away from human activity except when their nests are located near doors, windows, or other high traffic areas.

Nests of both yellowjacket and paper wasps typically are begun in spring by a single queen who overwinters and becomes active when the weather warms. She emerges in late winter/ early spring to feed and start a new nest. From spring to midsummer nests are in the growth phase, and the larvae require large amounts of protein. Workers forage mainly for protein at this time (usually in the form of other insects) and for some sugars. By late summer, however, the colonies grow more slowly or cease growth and require large amounts of sugar to maintain the queen and workers. So foraging wasps are particularly interested in sweet things at this time.

Normally, yellowjacket and paper wasp colonies only live one season. In very mild winters or in coastal California south of San Francisco, however, some yellowjacket colonies survive for several years and become quite large.

Yellowjackets

The term yellowjacket refers to a number of different species of wasps in the genera *Vespula* and *Dolichovespula* (family Vespidae). Included in this group of ground-nesting species are the western yellowjacket, *Vespula pensylvanica*, which is the most commonly encountered species and is sometimes called the "meat bee," and seven other species of *Vespula*. *Vespula vulgaris* is common in rotted tree stumps at higher elevations and *V. germanica* (the German yellowjacket) is becoming more common in many urban areas of California, where it frequently nests in houses. These wasps tend to be medium sized and black with jagged bands of bright yellow (or white in the case of the aerial-nesting

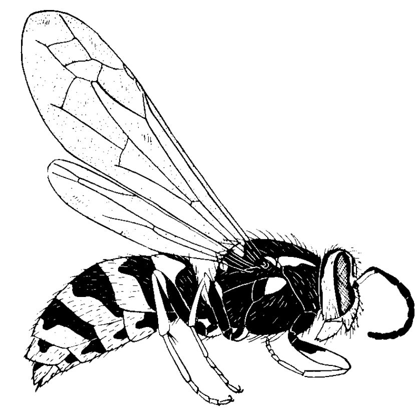

Figure 1. Western yellowjacket.

Dolichovespula [=Vespula] maculata) on the abdomen, and have a very short, narrow waist (the area where the thorax attaches to the abdomen).

Nests are commonly built in rodent burrows, but other protected cavities, like voids in walls and ceilings of houses, sometimes are selected as nesting sites. Colonies, which are begun each spring by a single reproductive female, can reach populations of between 1,500 and 15,000 individuals, depending on the species. The wasps build a nest of paper made from fibers scraped from wood mixed with saliva. It is built as multiple tiers of vertical cells, similar to nests of paper wasps, but enclosed by a paper envelope around the outside that usually contains a single entrance hole (Fig. 2). If the rodent hole is not spacious enough, yellowjackets will increase the size by moistening the soil and digging. Similar behavior inside a house

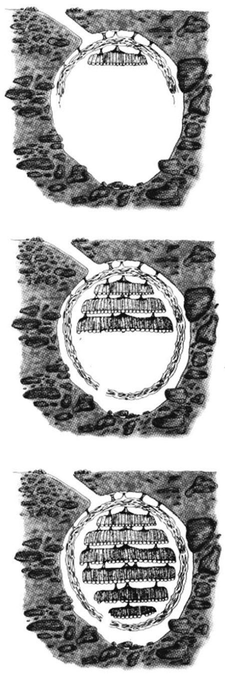

Figure 2. Yellowjacket nest in spring (top), summer (center), and early fall (bottom).

sometimes leads to a wet patch that develops into a hole in a wall or ceiling.

Immature yellowjackets are white, grublike larvae that become white pupae. The pupae develop adult coloring just before they emerge as adult wasps. Immatures are not normally seen unless the nest is torn open or a sudden loss of adult caretakers leads to an exodus of starving larvae.

Aerial-nesting yellowjackets, *Dolichovespula arenaria* and *D. maculata,* build paper nests that are attached to the eaves of a building or are hanging from the limb of a tree. The entrance is normally a hole at the bottom of the nest. These aerial nesters do not become scavengers at the end of the season, but they are extremely defensive when their nests are disturbed. Defending *D. arenaria* sometimes bite and/or sting, simultaneously. Wasp stingers have no barbs and can be used repeatedly, especially when the wasp gets inside clothing. As with any stinging incident, it is best to leave the area of the nest site as quickly as possible if wasps start stinging.

Paper Wasps

Paper wasps such as *Polistes fuscatus aurifer*, *P. apachus,* and *P. dominulus* are large (1 inch long), slender wasps with long legs and a distinct, slender waist (Fig. 3). Background colors vary, but most western species tend to be golden brown, or darker, with large patches of yellow or red. Preferring to live in or near orchards or vineyards, they hang their paper nests in protected areas, such as under eaves, in attics, or under tree branches or vines. Each nest hangs like an open umbrella from a pedicel (stalk) and has open cells that can be seen from beneath the nest (Fig. 4). White, legless, grublike larvae sometimes can be seen from below. Paper wasp nests rarely exceed the size of an outstretched hand and populations vary between 15 to 200 individuals. Most species are relatively unaggressive, but they can be a problem when they nest over doorways or in other areas of human activity, such as fruit trees.

Mud Daubers

Mud daubers are black and yellow, thread-waisted, solitary wasps that build a hard mud nest, usually on ceilings and walls, attended by a single female wasp. They belong to the family Sphecidae and are not social wasps but may be confused with them. They do not defend their nests and rarely sting. During winter, you can safely remove the nests without spraying.

INJURY OR DAMAGE

Concern about yellowjackets is based on their persistent, pugnacious behavior around food sources and their aggressive colony defense. Stinging behavior is usually encountered at nesting sites, but scavenging yellowjackets sometimes will sting if someone tries to swat them away from a potential food source. When scavenging at picnics or other outdoor meals, wasps will crawl into soda cans and cause stings on the lips, or inside the mouth or throat.

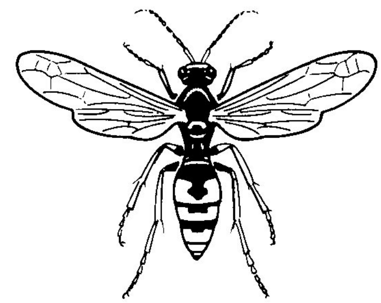

Figure 3. Paper wasp.

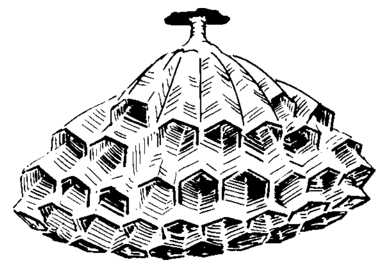

Figure 4. Paper wasp nest.

Responses to wasp stings vary from only short-term, intense sensations to substantial swelling and tenderness, some itching, or life-threatening allergic responses. All these reactions are discussed in detail in *Pest Notes: Bee and Wasp Stings* (see “References”). Of specific concern is a condition that results from multiple-sting encounters, sometimes unfamiliar to attending health professionals, that is induced by the volume of foreign protein injected and the tissue damage caused by destructive enzymes in wasp venom. Red blood cells and other tissues in the body become damaged; tissue debris and other breakdown products are carried to the kidneys, to be eliminated from the body. Too much debris and waste products can cause blockages in the kidneys, resulting in renal insufficiency or renal failure. Patients in this condition require medical intervention, even dialysis.

MANAGEMENT

Most social wasps provide an extremely beneficial service by eliminating large numbers of other pest insects through predation and should be protected and encouraged to nest in areas of little human or animal activity. Although many animals prey on social wasps (including birds, reptiles, amphibians, skunks, bears, raccoons, spiders, preying mantids, and bald-faced hornets), none provides satisfactory biological control in home situations.

The best way to prevent unpleasant encounters with social wasps is to avoid them. If you know where they are, try not to go near their nesting places. Wasps can become very defensive when their nest is disturbed. Be on the lookout for nests when outdoors. Wasps that are flying directly in and out of a single location are probably flying to and from their nest.

Scavenging wasps will not usually become a problem if there is no food around to attract them. When nuisance wasps are present in the outdoor environment, keep foods (including pet food) and drinks covered or inside the house and keep garbage in tightly sealed garbage cans. Once food is discovered by wasps, they will continue to hunt around that location long after the source has been removed.

If wasp nests must be eliminated, it is easiest and safest to call for professional help. In some areas of California, personnel from a local Mosquito and Vector Control District may be available to remove nests. To determine if this service is available in your area, call the California Mosquito and Vector Control Association at (916) 440-0826.

If a rapid solution to a severe yellowjacket problem is essential, seek the assistance of a professional pest control operator who can use microencapsulated baits to control these pests. Do-it-yourself options include trapping wasps in a baited trap designed for that purpose, early-season removal of nests, or spraying the nest or nesting site with an insecticide labeled for that use.

Trapping Wasps

Trapping wasps is an ongoing effort that needs to be initiated in spring and continued into summer and fall, especially when the yellowjacket population was large the previous year. In spring there is a 30- to 45-day period when new queens first emerge before they build nests. Trapping queens during this period has the potential to provide an overall reduction in the yellowjacket population for the season, and a study is currently underway to test this theory in some California Mosquito and Vector Control districts (see "Online References"). The more traps put out in spring on an area-wide basis to trap queens, the greater the likelihood of reducing nests later in the summer. Usually one trap per acre is adequate in spring for depletion trapping of queens; in fall, more traps may be necessary to trap scavenging wasps, depending on the size of the population. There are two types of wasp traps: lure and water traps.

Lure Traps. Lure traps are available for purchase at many retail stores that sell pest control supplies and are easiest to use. They work best as queen traps in late winter and spring. In summer and fall they may assist in reducing localized foraging workers, but they do not eliminate large populations. Lure traps contain a chemical that attracts yellowjackets into the traps, but common lures such as heptyl butyrate are not equally attractive to all species. Proteins such as lunchmeat can be added as an attractant and are believed to improve catches.

During spring, baited lure traps should have the chemical bait changed every 6 to 8 weeks. In summer, change the bait every 2 to 4 weeks; change bait more frequently when temperatures are high. Meats must be replaced more frequently because yellowjackets are not attracted to rotting meat. Also, periodically check the trap to remove trapped yellowjackets and make sure workers are still attracted to the trap.

Water Traps. Water traps are generally homemade and consist of a 5-gallon bucket, string, and protein bait (turkey ham, fish, or liver works well; do not use cat food because it may repel the yellowjackets after a few days). The bucket is filled with soapy water and the protein bait is suspended 1 to 2 inches above the water. (The use of a wide mesh screen over the bucket will help prevent other animals from reaching and consuming the bait.) After the yellowjacket removes the protein, it flies down and becomes trapped in the water and drowns. Like the lure trap, these traps also work best as queen traps in late winter to early spring. In summer and fall they may assist in reducing localized foraging workers but usually not to acceptable levels. Place them away from patio or picnic areas so wasps aren't attracted to your food as well.

Discouraging or Eliminating Nests

Early in the season, knocking down newly started paper wasp nests will simply cause the founding female to go elsewhere to start again or to join a neighboring nest as a worker. As there is little activity around wasp nests when they are first starting, they are very hard to find. Wasps are more likely to be noticed later after nests and populations grow. Nest removal for controlling subterranean or cavity-dwelling yellowjackets is not practical because the nests are underground or otherwise inaccessible.

Nest Sprays

Aerosol formulations of insecticides on the market labeled for use on wasp and hornet nests can be effective against both yellowjackets and paper wasps, but they must be used with extreme caution. Wasps will attack applicators when sensing a poison applied to their nests, and even the freeze-type products are not guaranteed to stop all wasps that come flying out. It is prudent to wear protective clothing that covers the whole body, including gloves and a veil over the face. In addition, you need to wear protective eyewear and other clothing to protect yourself from pesticide hazards. Wasps are most likely to be in the nest at night. But even after dark and using formulations that shoot an insecticide stream up to 20 feet, stinging incidents are likely. Underground nests can be quite a distance from the visible entrance and the spray may not get back far enough to hit the wasps. Partially intoxicated, agitated wasps are likely to be encountered at some distance from the nest entrance, even on the day following an insecticidal treatment. Hiring a pest control professional will reduce risks to you and your family; in some areas of California, this service may be available through your local Mosquito and Vector Control District.

REFERENCES

Akre, R. D., A. Green, J. F. MacDonald, P. J. Landolt, and H. G. Davis. 1981. *The Yellowjackets of America North of Mexico.* USDA Agric. Handbook No. 552. 102 pp.

Ebeling, W. 1975. *Urban Entomology*. Oakland: Univ. Calif. Agric. Nat. Sci.

Mussen, E. Feb 1998. *Pest Notes: Bee and Wasp Stings.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 7449. Also available online at www.ipm.ucdavis.edu/PMG/selectnewpest.home.html

Online References

California Mosquito and Vector Control Web site (www.sac-yolomvcd.com) for information on yellowjacket control

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

LAWN DISEASES: PREVENTION AND MANAGEMENT

Integrated Pest Management in the Home Landscape

Maintaining a healthy, vigorously growing lawn is the best way to prevent a severe disease outbreak in a turfgrass. A 5,000 square foot lawn contains about four million turfgrass plants, each requiring optimum amounts of water and fertilizer, the right mowing regime, and an aerated, well-drained soil. About 75 to 85% of common lawn diseases can be avoided altogether just by optimizing these practices to avoid stressed grass, which is much more susceptible to disease outbreaks than healthy grass.

For a disease to occur, all three sides of the "disease triangle" must be present (Fig. 1). Even if a disease-causing pathogen is present, infection will not occur unless the environment (temperature, quantity of water, etc.) is conducive to disease development and a susceptible host (species of grass) is available. Homeowners can prevent major disease infestations from occurring by planting locally adapted lawn grasses and providing optimal care. Selecting a turfgrass species that is adapted to the climate and intended use and following through with cultural practices that favor the grass rather than the pathogen are important steps a home gardener can take to avoid severe lawn diseases. Many common diseases reduce the quality of the lawn for only a short time and do not result in adverse long-term impacts. Often, when the weather becomes more favorable to growth of the turfgrass, the lawn will recover on its own if proper cultural practices are maintained. Few, if any, fungicide applications should be necessary under these conditions.

IDENTIFYING THE PROBLEM

The primary cause of lawn damage is often difficult to identify, especially if a long period of time has elapsed between when the damage actually occurred and when the problem was recognized. If the damage is severe, secondary pests or problems such as insects, pathogens, weeds, or environmental stress may be contributing to the observed symptoms. For this reason, it is a good idea to inspect your lawn once a week and immediately identify the cause of any damage.

Damage that resembles disease symptoms may result from incorrect watering, fertilizing, or mowing practices; dog urine and pesticides and other chemicals; soil characteristics that result in poor drainage and compaction; vertebrate or insect damage; extremely high or low temperatures; competing vegetation; or thatch that exceeds ½ inch in thickness. Irrigation problems are the most common cause of discolored lawns. Fixing broken sprinklers and conducting "can tests" (described in the irrigation section) to insure even water coverage may be all that is necessary to improve the health and appearance of the lawn. No amount of fungicide will control a problem that results from poor watering practices.

Lawn diseases are usually the result of pathogenic fungi that infect the blades, stems, or roots of turfgrass plants.

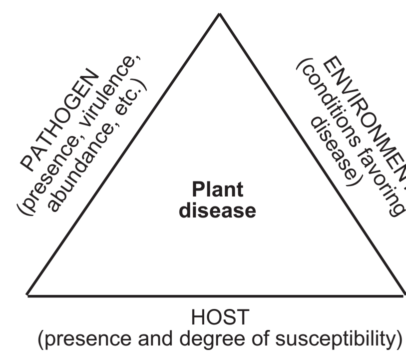

Figure 1. The disease triangle. All components must be present for disease to occur.

Typical signs and symptoms include leaf spots, white powdery growth, thin grass, and small to large areas of discolored or dying lawn. Diseases are often diagnosed by identifying symptoms of the disease and signs of the causal agent. Visible parts of the pathogen (called signs), such as whitish cottony growth or small, hard, dormant structures (sclerotia), are very useful in the identification process. Other typical symptoms of lawn diseases include frog-eye patterns (i.e., a circular area of dead grass with healthy grass in the center), leaf spots, rotted crowns and roots, yellow leaves, stunting, and wilting. Affected lawn areas can become discolored and lose density quickly. Appendix 1 lists and describes the most common diseases occurring in home lawns in California. Refer to *Turfgrass Pests*, listed in "References," and the UC IPM Web site (www.ipm.ucdavis.edu/PMG/selectnewpest.

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January 2002

turfgrass.html) for photographs of several common lawn diseases.

SELECTING A SUITABLE LAWN GRASS

All types of turfgrass have positive and negative characteristics. There is no one perfect turfgrass suitable for all lawns. The type of grass you choose for your lawn should be compatible with your climate, anticipated use and maintenance level, and aesthetic desires; it also should have some resistance to common diseases.

Make every effort to choose a grass that grows well under your conditions. For instance, too much shade causes stress that can lead to disease development. Similarly, some species are more heat or drought tolerant than others.

New and improved cultivars of lawn grasses offering greater disease resistance, color, texture, density, and uniformity have been developed over the past several years. Contact a reputable nursery or the UC Cooperative Extension office in your county for specific recommendations. Also see the publication *Turfgrass Selection for the Home Landscape*, listed in "References."

CULTURAL PRACTICES TO REDUCE LAWN DISEASE

To prevent lawn diseases, employ cultural practices that promote a dense, vigorous, actively growing grass with good recuperative ability. Cultural practices that promote healthy lawns and help them to resist major disease outbreaks include irrigation, fertilization, mowing, soil cultivation, and thatch removal. Appendix 1 outlines cultural practices that are recommended to prevent specific diseases.

Irrigation

Much of California has a Mediterranean climate characterized by rainfall in winter and spring and very little precipitation during summer and fall. Throughout the state, lawns require irrigation. It is important to follow sound watering practices (whether hand-watering or employing an automated system) to promote an environment favoring growth of the lawn rather than disease outbreak. Applying too much or not enough water can result in unhealthy, slow-growing grass that is vulnerable to pathogens. Waterlogged soils are poorly aerated, which restricts root growth, promotes some diseases, and allows algae and moss to thrive. In general, a deeply watered lawn develops a deeper and more extensive vertical root system, which provides it with greater drought and disease resistance than a shallowly watered lawn.

Turfgrasses vary in water requirements. Warm-season turfgrasses (bermudagrass, zoysiagrass, and St. Augustinegrass) are more drought resistant than cool-season grasses (tall fescue, perennial ryegrass, Kentucky bluegrass) and require about 20% less water. See Table 1 for information on how many minutes to water warm- and cool-season lawns each week in various parts of California, based on the output of the irrigation system (or hose-end sprinkler). It is best to water the lawn until runoff just begins, and avoid watering each day. The number of times to water each week depends on how long the irrigation system can run before water just starts to puddle or run off the soil surface laterally. For example, if a grass needs 40 minutes of irrigation each week, but runoff begins after 20 minutes, then water twice a week for 20 minutes. In cases where soil takes up water so slowly that runoff occurs before 10 minutes, water cycling is necessary. To cycle, irrigate until runoff just begins, turn the system off, and repeat the process in 30 minutes before the soil surface dries out. Several cycles per day may be necessary to apply the desired amount of water.

To determine sprinkler output, conduct a "can tests" by setting small, empty, straight-sided, equal-sized containers such as tuna or cat food cans on top of your lawn every 10 to 15 feet between sprinkler heads operated by the same valve (Fig. 2) and run the system for 15 minutes. After 15 minutes, turn off the system and measure the amount of water in each can with a ruler to determine the average amount of water per can. (To find the average, add up the measurements from all the cans and divide this number by the number of cans used.) Multiply this number by 4 to calculate the sprinkler output rate per hour. Compare this number to the outputs listed in Table 1 to determine how many minutes you need to irrigate weekly. Conducting "can tests" regularly is also useful to

SAMPLING FOR COMMERCIAL LABORATORY DIAGNOSIS

When a disease outbreak in a home lawn is suspected, the best course of action may be to seek the professional services of a plant disease diagnostic laboratory. Accurately identifying the problem before symptoms become severe allows for corrective action to be taken before there is an unnecessary loss of large lawn areas. Contact a nursery or your local UC Cooperative Extension office for a list of diagnostic laboratories.

An accurate diagnosis depends on the quality of the sample submitted, so the way a sample is taken is important. Collect entire grass plant samples (leaves, stems, roots, and soil) from several lawn areas that appear to exhibit different stages of the observed symptoms. It is a good idea to sample on the edge of an infected area, making sure to include plants that are just beginning to show symptoms. Also, remember that the pathogen is not always active in the part of the grass plant exhibiting disease symptoms, so be sure to include the entire plant. For example, symptoms observed in the foliage such as chlorosis (yellowing) or wilting may be associated with a vascular wilt or a root rot.

Place samples in a plastic bag and carefully label it. It is useful to place a moist paper towel in the bag to keep the samples as fresh as possible during transport. Do not allow roots to dry out. Attach a written description of the type of lawn and symptoms that you observe. Also include information on cultural management practices, any chemical applications that have been made, and any other relevant information that might be useful in making an accurate diagnosis as well as the date the sample was collected and your name and contact information.

Keep the samples cool and moist, and submit them as soon as possible; refrigerate as necessary. (Do not freeze!) Priority or Next Day delivery is optimum.

Table 1. Minutes to Irrigate Warm- and Cool-season Turfgrass per Week in California.[1]

SOUTHERN COAST

	Warm-season Turfgrasses Minutes to irrigate/week if hourly sprinkler output is:					*Cool-season Turfgrasses* Minutes to irrigate/week if hourly sprinkler output is:			
	0.5 in	1.0 in	1.5 in	2.0 in		0.5 in	1.0 in	1.5 in	2.0 in
JAN	44	22	15	11	JAN	59	29	20	15
FEB	57	28	19	14	FEB	76	38	25	19
MAR	63	32	21	16	MAR	84	42	28	21
APR	76	38	25	19	APR	101	50	34	25
MAY	88	44	29	22	MAY	118	59	39	29
JUN	95	47	32	24	JUN	126	63	42	32
JUL	107	54	36	27	JUL	143	71	48	36
AUG	95	47	33	24	AUG	126	63	42	32
SEP	82	41	27	20	SEP	109	55	36	27
OCT	69	35	23	17	OCT	92	46	31	23
NOV	50	25	17	13	NOV	67	34	22	17
DEC	38	19	13	9	DEC	50	25	17	13

SOUTHERN INLAND VALLEYS

	Warm-season Turfgrasses Minutes to irrigate/week if hourly sprinkler output is:					*Cool-season Turfgrasses* Minutes to irrigate/week if hourly sprinkler output is:			
	0.5 in	1.0 in	1.5 in	2.0 in		0.5 in	1.0 in	1.5 in	2.0 in
JAN	52	21	14	10	JAN	56	28	19	14
FEB	57	28	19	14	FEB	75	38	25	19
MAR	80	40	27	20	MAR	106	53	35	27
APR	96	48	32	24	APR	128	64	43	32
MAY	119	60	40	29	MAY	159	80	53	40
JUN	144	72	48	36	JUN	193	96	64	48
JUL	165	83	55	41	JUL	221	110	74	55
AUG	155	77	52	39	AUG	207	103	69	52
SEP	124	62	41	31	SEP	165	82	55	42
OCT	88	44	29	22	OCT	117	59	39	29
NOV	54	27	18	14	NOV	73	36	24	18
DEC	42	21	14	10	DEC	55	28	19	14

SOUTHERN DESERTS

	Warm-season Turfgrasses Minutes to irrigate/week if hourly sprinkler output is:					*Cool-season Turfgrasses* Minutes to irrigate/week if hourly sprinkler output is:			
	0.5 in	1.0 in	1.5 in	2.0 in		0.5 in	1.0 in	1.5 in	2.0 in
JAN	54	27	18	14	JAN	65	32	22	17
FEB	75	38	25	19	FEB	90	46	30	23
MAR	121	61	40	30	MAR	145	73	48	36
APR	165	83	55	41	APR	198	100	66	49
MAY	211	106	70	53	MAY	253	127	84	64
JUN	243	121	81	61	JUN	292	145	97	73
JUL	251	126	84	63	JUL	301	151	101	76
AUG	218	109	73	54	AUG	262	131	88	65
SEP	180	90	60	45	SEP	216	108	72	54
OCT	121	61	40	30	OCT	145	73	48	36
NOV	69	35	23	17	NOV	83	42	28	20
DEC	43	22	14	11	DEC	52	26	17	13

CENTRAL COAST

	Warm-season Turfgrasses Minutes to irrigate/week if hourly sprinkler output is:					*Cool-season Turfgrasses* Minutes to irrigate/week if hourly sprinkler output is:			
	0.5 in	1.0 in	1.5 in	2.0 in		0.5 in	1.0 in	1.5 in	2.0 in
JAN	38	19	13	9	JAN	50	25	17	13
FEB	50	25	17	13	FEB	67	34	22	17
MAR	63	32	21	16	MAR	84	42	28	21
APR	88	44	29	22	APR	118	59	39	29
MAY	101	50	34	25	MAY	134	67	45	34
JUN	113	57	38	28	JUN	151	76	50	38
JUL	95	47	32	24	JUL	126	63	42	32
AUG	113	57	38	28	AUG	151	76	50	38
SEP	95	47	32	24	SEP	126	63	42	32
OCT	69	35	23	17	OCT	92	46	31	23
NOV	50	25	17	13	NOV	67	34	22	17
DEC	38	19	13	9	DEC	50	25	17	13

1. Irrigation is not needed when precipitation provides equivalent or more water.

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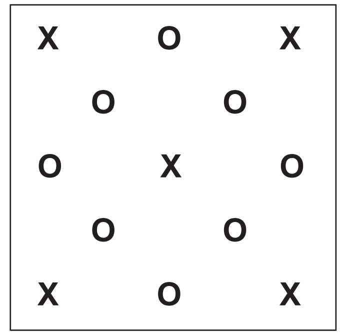

Figure 2. Layout of a catch-can test, showing placement of catch cans (O) and sprinkler heads (X).

determine how evenly irrigation water is distributed over the area watered and allows for sprinkler-head misalignments and other mechanical problems to be discovered and corrected.

The best time to water is early in the morning, when evaporation rates are lowest and water pressure is at its peak. Irrigating in the afternoon is wasteful because of higher evaporation rates, and prolonged damp conditions in the evening may encourage disease development. Remember that irrigation requirements change from month to month and may not be needed at all if it has rained. Reset your sprinkler system to meet your lawn's changing irrigation needs.

Fertilization

Applying the correct amount of fertilizer is an important aspect of maintaining a healthy, dense lawn with improved disease resistance. Fertilization influences turfgrass growth, which in turn influences the recuperative ability of stressed grass. All turfgrasses require nitrogen, and certain sites may also require phosphorus, potassium, and iron on a regular basis. Applying too much nitrogen, especially in a highly soluble, fast-release form, can result in excessive, succulent leaf and stem growth, leading to increased opportunities for fungal penetration that may result in diseases such as brown patch, Pythium blight, and leaf spot. Over-fertilized lawns also require more

Table 1. Minutes to Irrigate Warm- and Cool-season Turfgrass per Week in California, cont.

SAN JOAQUIN VALLEY

	Warm-season Turfgrasses					Cool-season Turfgrasses			
	Minutes to irrigate/week if hourly sprinkler output is:					Minutes to irrigate/week if hourly sprinkler output is:			
	0.5 in	1.0 in	1.5 in	2.0 in		0.5 in	1.0 in	1.5 in	2.0 in
JAN	19	9	6	5	JAN	25	13	8	06
FEB	38	19	13	9	FEB	50	25	17	13
MAR	69	35	23	17	MAR	92	46	31	23
APR	101	50	34	25	APR	134	67	45	34
MAY	132	66	44	33	MAY	176	88	59	44
JUN	164	82	55	41	JUN	218	109	73	55
JUL	170	85	57	43	JUL	227	113	76	57
AUG	145	72	48	36	AUG	193	97	64	48
SEP	113	57	38	28	SEP	151	76	50	38
OCT	69	35	23	17	OCT	92	46	31	23
NOV	32	16	11	8	NOV	42	21	14	11
DEC	13	6	4	3	DEC	17	8	06	4

SACRAMENTO VALLEY

	Warm-season Turfgrasses					Cool-season Turfgrasses			
	Minutes to irrigate/week if hourly sprinkler output is:					Minutes to irrigate/week if hourly sprinkler output is:			
	0.5 in	1.0 in	1.5 in	2.0 in		0.5 in	1.0 in	1.5 in	2.0 in
JAN	19	9	6	5	JAN	25	13	8	6
FEB	44	22	15	11	FEB	59	29	20	15
MAR	69	35	23	17	MAR	92	46	31	23
APR	101	50	34	25	APR	134	67	45	34
MAY	126	63	42	32	MAY	168	84	56	42
JUN	158	79	53	39	JUN	210	105	70	53
JUL	164	82	55	41	JUL	218	109	73	55
AUG	145	72	48	36	AUG	193	97	64	48
SEP	113	57	38	28	SEP	155	76	50	38
OCT	82	41	27	20	OCT	109	55	36	27
NOV	38	19	13	9	NOV	50	25	17	13
DEC	19	9	6	5	DEC	25	13	8	6

SIERRA MOUNTAINS

Warm-season Turfgrasses		Cool-season Turfgrasses			
		Minutes to irrigate/week if hourly sprinkler output is:			
		0.5 in	1.0 in	1.5 in	2.0 in
	JAN	31	15	10	8
	FEB	43	22	14	11
	MAR	79	39	26	20
	APR	124	62	41	31
	MAY	164	82	55	41
NOT RECOMMENDED	JUN	207	103	69	52
	JUL	231	115	77	58
	AUG	198	99	66	50
	SEP	141	70	47	35
	OCT	96	48	32	24
	NOV	40	20	13	10
	DEC	20	10	7	5

NORTHEASTERN MOUNTAIN VALLEYS

Warm-season Turfgrasses		Cool-season Turfgrasses			
Minutes to irrigate/week if hourly sprinkler output is:					
		0.5 in	1.0 in	1.5 in	2.0 in
	JAN	17	8	6	4
	FEB	34	17	11	8
	MAR	59	29	20	15
	APR	101	50	34	25
	MAY	134	67	45	34
NOT RECOMMENDED	JUN	168	84	56	42
	JUL	210	105	70	53
	AUG	176	88	59	44
	SEP	126	63	42	32
	OCT	76	38	25	19
	NOV	25	13	9	6
	DEC	17	9	6	4

1. Irrigation is not needed when precipitation provides equivalent or more water.

Continued on next page

frequent mowing and water. Conversely, lawns grown under nitrogen-deficient conditions are prone to dollar spot, rust, and red thread diseases.

For moderate, even growth, apply a total of 4 to 6 pounds of actual nitrogen per 1,000 square feet of lawn area annually. Avoid applying more than 1 pound of actual nitrogen per application. Sandy soils require the same amount of nitrogen as clay soils, but at lower rates and applied more frequently. Fertilizer should be applied during the active growing season of the grass (generally during spring, summer, and early fall for warm-season grasses and during fall and spring for cool-season lawns).

Some soils also benefit from the addition of phosphorus and potassium. Potassium in particular may help to prevent disease because it increases the turfgrasses' resistance to adverse environmental conditions (heat, drought, etc.).

Mowing

Maintaining a lawn at the recommended mowing height will improve its ability to resist diseases as well as give it greater aesthetic appeal. The frequency with which the lawn is mowed should be based on the growth rate of the grass. Mow lawns often enough so that no more than one-third the length of the grass blade is removed at any time. Removing too much of the grass blade can increase the susceptibility to several diseases by depleting food reserves in the plant, making it difficult for the plant to recover from stress and injury. Repeated scalping greatly reduces the vigor of a turfgrass. Maintain sharp mower blades to avoid fungal infections that result from pathogen entry into created wounds. When grass is mowed regularly, clippings can be left on the lawn, a practice called "grasscycling." Grasscycling has not been found to significantly increase thatch or disease incidence. For additional information, see *Mowing Your Lawn and 'Grasscycling'* listed in "References."

Table 1. Minutes to Irrigate Warm- and Cool-season Turfgrass per Week in California, cont.

NORTHERN COAST

Warm-season Turfgrasses		Cool-season Turfgrasses: Minutes to irrigate/week if hourly sprinkler output is:			
		0.5 in	1.0 in	1.5 in	2.0 in
	JAN	15	7	5	4
	FEB	36	18	12	9
	MAR	55	27	18	14
	APR	67	34	22	17
	MAY	88	44	29	22
NOT RECOMMENDED	JUN	97	48	32	24
	JUL	95	47	32	24
	AUG	90	45	30	23
	SEP	76	38	25	19
	OCT	48	24	16	12
	NOV	32	16	11	8
	DEC	21	11	7	5

NORTHERN INLAND VALLEYS

	Warm-season Turfgrasses: Minutes to irrigate/week if hourly sprinkler output is:					Cool-season Turfgrasses: Minutes to irrigate/week if hourly sprinkler output is:			
	0.5 in	1.0 in	1.5 in	2.0 in		0.5 in	1.0 in	1.5 in	2.0 in
JAN	19	9	6	5	JAN	25	13	8	6
FEB	32	16	11	8	FEB	42	21	14	11
MAR	50	25	17	13	MAR	67	34	22	17
APR	69	35	23	17	APR	92	46	31	23
MAY	101	50	34	25	MAY	134	67	45	34
JUN	126	63	42	32	JUN	168	84	56	42
JUL	132	66	44	33	JUL	176	88	59	44
AUG	120	60	40	30	AUG	160	80	53	40
SEP	95	47	32	24	SEP	126	63	42	32
OCT	57	28	19	14	OCT	76	38	25	19
NOV	25	13	8	6	NOV	34	17	11	8
DEC	13	6	4	3	DEC	17	8	6	4

1. Irrigation is not needed when precipitation provides equivalent or more water.

Soil Cultivation and Thatch Removal

Soil compaction reduces root growth as well as the grasses' recuperative ability, thus increasing a lawn's relative susceptibility to diseases. Soil cultivation, such as coring or aerification, will improve shoot and root growth and recuperative ability, and decrease the likelihood of disease and insect damage.

Thatch is a partially decomposed layer comprised of roots, stems, rhizomes, crowns, and stolons situated above the soil surface. Up to a ½-inch layer of thatch is beneficial and provides insulation to roots, reduces soil water evaporation, cushions playing surfaces, and may prevent soil compaction. However, thatch layers greater than ½ inch should be removed to avoid restricted water entry into the root zone, resulting in drought stress.

Several turfgrass pathogens can survive in the thatch layer, including those that cause summer patch, leaf spot, and melting-out diseases. Bermudagrass, Kentucky bluegrass, and kikuyugrass produce more thatch than most other turfgrasses and require regular dethatching. Equipment rental businesses often carry dethatching (verticutting) machines that are specifically designed to remove thatch from home lawns.

REFERENCES

Gibeault, V. A., R. L. Baldwin, and K. D. Gowans. 1984. *Lawn Aeration and Thatch Control.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 2586.

Grebus M., and J. Hartin. Mar 2000. Diseases from *UC IPM Pest Management Guidelines: Turfgrass*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3365-T. Also available online at http://www.ipm.ucdavis.edu/PMG/selectnewpest.turfgrass.html

Harivandi, A., and V. A. Gibeault. 1999. *Mowing Your Lawn and 'Grasscycling.'* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 8006. Available online at http://anrcatalog.ucdavis.edu/specials.ihtml

McCain, A. H., R. M. Endo, H. D. Ohr. 1989. Fungal diseases. In A. D. Ali and C. L. Elmore, comps. *Turfgrass Pests*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 4053.

Harivandi, A., V. A. Gibeault, M. J. Henry, L. Wu, P. M. Geisel, and C. L. Unruh. 2001. *Turfgrass Selection for the Home Landscape.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 8035. Available online at http:/anrcatalog.ucdavis.edu/specials.ihtml

Appendix 1. Common Lawn Diseases in California.

DISEASE	PATHOGEN	SUSCEPTIBLE GRASSES	SYMPTOMS	CONDITIONS FAVORING DISEASE	PREVENTION	CHEMICAL TREATMENT[1]
dollar spot	*Sclerotinia homeocarpa, Lanzia* sp., *Moellerodiscus* sp.	bermudagrass, fescue, ryegrass, annual bluegrass	small, circular spots from 1–5 inches in diameter; spots may merge to form large, irregular areas; leaves appear watersoaked, then brown, often exhibiting a reddish band across the leaf; fine, white cobwebby threads may be seen in early morning	moderate temperatures (60° to 80°F), excess moisture or water stress; fog; thatch; survives in soil as hard, dark structures (sclerotia)	apply up to 6 lb actual nitrogen/1,000 sq ft/year; reduce thatch; water appropriate length of time to a depth of 4–6 inches but don't extend interval too long; maintain air circulation; compost top dressings may suppress disease	if present in previous years, fungicide may be useful; apply in early spring or fall before symptoms occur
fairy ring	*Agrocybe* spp., *Marasmius oreades, Lepiota* spp.	all lawn grasses	a dark green band of turf develops in a circle (4 inches up to 30 ft) or semicircle in moist turf; mushrooms may or may not be present; an area of brown, dying grass may occur just behind the dark green band; a second ring of dying grass may appear inside the circle; weeds commonly invade	soils high in thatch or undecomposed organic matter containing lignin	apply adequate nitrogen; aerate soil for better water penetration, water heavily in holes for several days; verticut if more than ½ inch thatch accumulates; rake mushrooms to improve appearance of turf; to eliminate, remove turf and root zone containing white, cottony mass to a depth of 12 inches and 2 ft beyond outer edge of the ring; refill with clean soil and re-seed or re-sod	fungicides available, but control has been erratic
Fusarium blight	*Fusarium culmorum, F. tricinctum*	bluegrasses	small, circular, grayish green areas, ranging from a few inches up to a foot in diameter; some plants in center may survive, giving a frog-eye appearance; the crown or basal area of dead stems has a reddish rot and is hard and tough; dead foliage appears bleached	daytime temperatures of 85° to 95°F; drought-stressed areas in full sun; survives in thatch and grass residues	water appropriate length of time; don't apply more than 1 lb nitrogen/1,000 sq ft/ application or more than 6 lb annually; use a mixture of 20% perennial ryegrass when seeding bluegrass; mow at highest recommended height; verticut if more than ½ inch thatch	fungicides do not give complete control in Calif.; make spring application before or just after symptoms appear
Fusarium patch (pink snow mold)	*Microdochium nivale*	annual bluegrass, bluegrasses, fescues, ryegrasses, zoysiagrass	circular patches of 1–2 inches that may enlarge to 12 inches; leaves first appear watersoaked, then reddish brown, and finally bleached; minute gelatinous spore masses sometimes seen on dead leaves; white or pinkish fungal threads may be seen in early morning; more prevalent in central and northern Calif.	cool temperatures (40° to 60°F) and moist conditions; high nitrogen applications in fall; neutral or alkaline soil pH; pathogen survives in grass residues	reduce shade and improve soil aeration and water drainage; water appropriate length of time; avoid excess nitrogen, especially in fall; maintain soil pH between 6.5 to 6.7; high levels of potassium suppress disease	if a serious problem in past, have licensed applicator apply fungicide in fall before symptoms appear

1. For currently registered fungicides, see *UC IPM Pest Management Guidelines: Turfgrass* listed in "References."

Continued on next page

Apprendix 1. Common Lawn Diseases in California, cont.

DISEASE	PATHOGEN	SUSCEPTIBLE GRASSES	SYMPTOMS	CONDITIONS FAVORING DISEASE	PREVENTION	CHEMICAL TREATMENT[1]
leaf spot	*Bipolaris* spp.	bluegrasses, fescues, ryegrasses	circular to elongated brownish spots with brown centers and dark brown or purple borders on leaf blades, sheaths, and stems; crowns and roots frequently have a dark brown rot; crown-infected plants may die in hot, windy weather, leaving thinned areas throughout the turf; spores are windborne	warm temperatures (70° to 90°F), high humidity, and closely clipped turfgrass; most severe with high nitrogen fertilization	reduce shade; improve soil aeration and water drainage; avoid dry spots and too much nitrogen fertilizer; maintain as high a cutting height as possible	fungicides available but often not warranted
Pythium blight (Grease spot)	*Pythium* spp.	all grasses	small, circular spots (2–6 inches) that run together; blackened leaf blades rapidly wither, turn reddish brown, lie flat, stick together, and appear greasy; roots may be brown; under humid conditions, masses of fungal mycelium may appear; survives as spores in soil for long periods	low spots that remain wet; temperatures in the 80° to 95°F range	reduce shading; improve soil aeration and water drainage; water appropriate length of time; avoid mowing wet grass and applying high levels of nitrogen during hot, humid weather	fungicides available but primarily prevented by cultural practices in Calif.
Rhizoctonia blight	*Rhizoctonia solani*	bermudagrasses, bluegrass, fescues, ryegrasses, zoysia, annual bluegrass	first appears as small, irregular brown patches or rings that may enlarge to many feet in diameter; centers may recover resulting in rings of diseased grass; leaves and sheaths become watersoaked, wilt, turn light brown, and die; in light infestations, roots usually not infected and plants often recover; soil-inhabiting fungus that forms fine, fungal threads in soil or on turfgrass	excess thatch and mat along with high temperatures (80° to 95°F); high humidity; soft, lush growth due to excessive nitrogen; most common in warm, inland areas	reduce shading and improve soil aeration and water drainage; water appropriate length of time to a depth of 4–6 inches; avoid excess nitrogen; maintain thatch less than ½ inch	fungicide useful if disease severe in past or for seedlings in young turf
spring dead spot	*Leptosphaeria korrae*	bermudagrass (mostly hybrid varieties)	circular areas of dead grass 6–12 inches in diameter appear in spring when growth resumes; spots may coalesce to form large areas; typically affects turfgrass more than 2 years old	affects dormant plants; most severe when temperatures 50° to 57°F; survives as sclerotia and in infected plant parts	remove dead grass; fertilize in summer to maintain vigor; don't overfertilize in late summer; water appropriate length of time; overseeding with ryegrass may be beneficial	fungicides available but primarily prevented by cultural practices in Calif.
summer patch	*Magnaporthe poae*	fine fescues; bluegrasses	circular yellow or tan areas of dead and dying plants up to 1 ft in diameter; may have green, apparently healthy plants in center; roots, crowns, stolons have dark brown fungal hyphae on them; vascular discoloration and cortical rot occur in later stages	high temperatures (85° to 95°F) in late spring; most severe when turf is mowed low or when soil moisture is excessive	aerate soil and apply slow-release nitrogen; improve drainage; reduce compaction; water appropriate length of time; do not mow too low; control thatch; reduce soil pH if higher than 7	systemic fungicides in fall usually necessary when disease has been severe

1. For currently registered fungicides, see *UC IPM Pest Management Guidelines: Turfgrass* listed in "References."

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

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WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

CALIFORNIA GROUND SQUIRREL

Integrated Pest Management for Home Gardeners and Landscape Professionals

The California ground squirrel, *Spermophilus beecheyi* (Fig. 1), is one of the most troublesome pests to homeowners and gardeners. It is found in nearly all regions of California except for the Owens Valley southward into the desert regions.

IDENTIFICATION

Ground squirrels are easily identified as they forage aboveground near their burrows. The ground squirrel's body measures 9 to 11 inches and its semi-bushy tail adds another 5 to 9 inches in length. The fur is brownish gray and speckled with off-white along the back; the sides of the head and shoulders are light gray to whitish. One subspecies that occupies most of northern California has a dark, triangular-shaped patch on its back between the shoulders; this patch is missing from other species. While ground squirrels are similar in appearance to tree squirrels and may climb trees, when frightened they will always retreat to a burrow, whereas tree squirrels will climb a tree or tall structure and never use a burrow.

BIOLOGY AND BEHAVIOR

Ground squirrels live in a wide variety of natural habitats but usually avoid thick chaparral, dense woods, and wet areas. Populations may be particularly high in grazed rangelands and in areas disturbed by humans such as road or ditchbanks, fence rows, around buildings, and in or bordering many crops.

Ground squirrels live in a burrow system where they sleep, rest, rear young, store food, and avoid danger. The burrow openings are about 4 inches in diameter, but can vary considerably. The burrows may be 5 to 30 feet or more in length and may go 2 to 4 feet below the soil surface. Often there is more than one opening in a burrow system. Ground squirrels live in colonies that may include several dozen animals in a complex of burrows. More than one squirrel may live in a burrow.

Ground squirrels are active during the day, mainly from mid-morning through late afternoon, especially on warm, sunny days. Ground squirrels have two periods of dormancy during the year. During winter months most ground squirrels hibernate, but some young may be active at this time, especially in areas where winters are not severe. During the hottest times of the year most adults go into a period of inactivity, called estivation, that may last a few days to a week or more. During these periods, the burrow appears open at the entrance but the squirrel plugs it with soil near the nest.

Ground squirrels breed once a year, averaging seven to eight per litter. Timing of breeding varies with location: in southern California breeding begins in December, in the Central Valley in February through April, and somewhat later in the mountain ranges. Aboveground activity by adults is at a maximum at the height of the breeding season. The young are born in the burrow and grow rapidly; by about 6 weeks of age they usually emerge from the burrow. At 6 months of age they resemble adults.

Ground squirrels are primarily herbivorous. Their diet changes with the season. After emergence from hibernation, they feed almost exclusively on green grasses and herbaceous plants. When annual plants begin to dry and produce seed, squirrels switch to seeds, grains, and nuts, and begin to store food. Ground squirrels usually forage close to their burrows. Their home range typically is within a 75-yard radius of their burrow.

Figure 1. California ground squirrels.

DAMAGE

Ground squirrels damage many food-bearing and ornamental plants. Particularly vulnerable are grains and nut and fruit trees such as almond, apple, apricot, orange, peach, pistachio, prune, and walnut. Ground squirrels will enter gardens and devour vegetables in the seedling stage. They may damage young shrubs, vines, and trees by gnawing bark, girdling trunks, eating twigs and leaves, and burrowing around roots. Ground squirrels will gnaw on plastic sprinkler heads and irrigation lines. They also eat the eggs of ground-nesting birds and may limit attempts to attract quail to the yard.

Burrowing can be quite destructive. Burrows and mounds make it difficult to mow, and they present hazards to machinery, pedestrians, and livestock. Burrows around trees and shrubs can damage and desiccate roots, and sometimes topple trees. Burrows beneath buildings and other structures sometimes necessitate repair.

Ground squirrels can harbor diseases harmful to humans, particularly when squirrel populations are dense. A major concern is bubonic plague transmitted to humans by fleas carried on the squirrels. Ground squirrels are susceptible to plague, which has wiped out entire colonies. If you find unusual numbers of squirrels or other rodents dead for no apparent reason, notify public health officials. Do not handle dead squirrels under these circumstances.

LEGAL STATUS AND LEGAL CONSIDERATIONS

Ground squirrels are classified as nongame mammals by the California Fish and Game Code. Nongame mammals injuring growing crops or other property may be controlled in any legal manner by the owner or tenant; tree squirrels, on the other hand, are classified as game animals and have a hunting season.

Note that the Mohave ground squirrel (*S. mohavensis*) and the San Joaquin antelope squirrel (*Ammospermophilus nelsoni*) are classified as *threatened* by the U.S. Fish and Wildlife Service and are protected. Although neither of these relatively small squirrels is likely to be misidentified as the much larger California ground squirrel, their ranges could overlap in some areas. The endangered San Joaquin kit fox (*Vulpes macrotis mutica*), several endangered species of kangaroo rats, the riparian brush rabbit (*Sylvilagus bachmani riparius*), riparian wood rat (*Neotoma fuscipes riparia*), as well as some endangered amphibians and reptiles, are also found within California ground squirrels' range and could be impacted by some squirrel control techniques. Before using pesticides for ground squirrel control, *read the product label* to determine if any restrictions exist on rodent control within the ranges of these and other endangered and protected animals. Also, if the kit fox is found in your county (for a range map, see the California Department of Pesticide Regulation's Web site listed in "References"), contact your county agricultural commissioner for additional information.

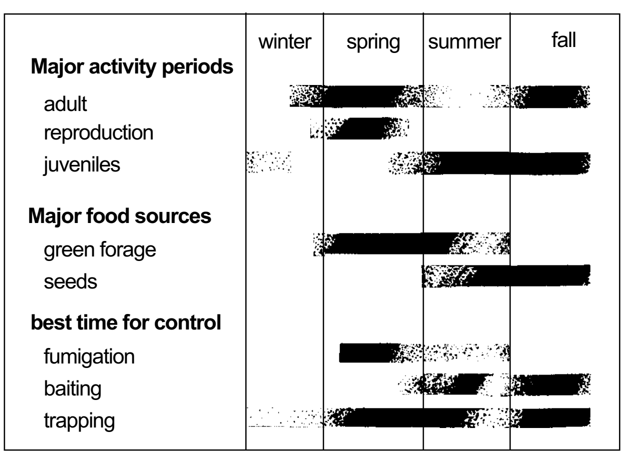

Figure 2. The best time for a specific type of control depends on the activity periods and food sources of the ground squirrel.

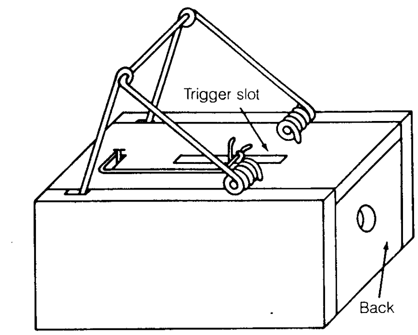

Figure 3. Box trap.

MANAGEMENT

The selection of control procedures is heavily influenced by the unique life cycle and behavior of the ground squirrel. For example, baiting with treated grain is effective in summer and fall because squirrels primarily feed on seeds during this period. Fumigation is most effective in spring when soil is moist, which helps seal gasses in the burrow system. Fumigating at this time also is more effective because squirrels are removed before they can reproduce. Figure 2 shows the yearly activities of the California ground squirrel and times when baiting, trapping, and fumigation are most effective.

Trapping

Traps are practical for control when squirrel numbers are low to moderate. Live-catch traps are not recommended because they present the problem of how to dispose of the live animals. Because ground squirrels carry diseases and are agricultural pests, the California Fish and Game Code specifies that it is illegal to release them elsewhere without a written permit.

There are several types of traps that kill ground squirrels, including box traps, Conibear traps, and tunnel traps. Box traps (Fig. 3) should be placed on the ground near squirrel burrows or

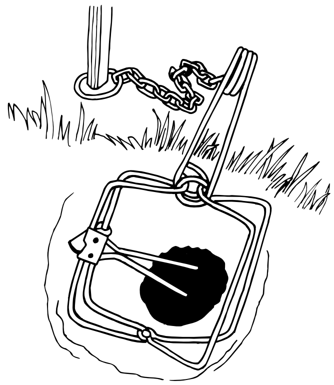

Figure 4. To use a Conibear trap, dig a slice of soil from the entrance so the trap will fit flush to the edges of the burrow entrance.

runways. Bait these traps with walnuts, almonds, oats, barley, or melon rinds. Place the bait well behind the trigger or tied to it. Bait the traps but do not set them for several days so the squirrels become accustomed to them. After the squirrels are used to taking the bait, rebait and set the traps.

To reduce hazards to children, pets, poultry, and nontarget wildlife, place box-type traps in a covered box with a 3-inch diameter entrance. Put the box near active burrows with signs of recent diggings. Inactive burrows will be filled with leaves, old straw, or have cobwebs across the entrance.

The Conibear trap (No. 110) with a 4½-by-4½-inch jaw spread is also an effective kill trap (Fig. 4). The wire trigger can be baited but is usually left unbaited. Place the trap directly in the burrow opening so the squirrel must pass through it, tripping the trigger. It may be necessary to partially fill in the burrow entrance around the outer edges of the trap with soil to prevent the squirrel from slipping around the outside of the trap. Closing all other burrows with soil may hasten success by directing the squirrel to the remaining open burrow with the trap. Attach the Conibear trap to a stake to prevent a scavenger from carrying off the trap and squirrel. With this type of trap, leaving the trap baited but unset has little effect on trapping success.

Inspect traps at least once a day and remove dead squirrels. Do not handle the carcasses without protective gear. Use a plastic bag slipped over each hand and arm as a glove. Once the squirrel is removed from the trap, hold the animal with one hand and turn the bag inside out while slipping it off your arm and hand. If possible, keep small children and pets out of the area while traps are in use. In kit fox areas, spring all Conibear traps before nightfall and reset them the following morning.

Fumigation

Fumigation is a relatively safe method of control. As with any pesticide, *read and follow label instructions* with particular regard for nontarget species and safety factors. With some fumigants, flames may be produced, creating a fire danger. Do not use such fumigants where a significant fire hazard exists, such as near buildings, dry grass, or other flammable materials. To avoid the accumulation of fumes in enclosed areas, never fumigate beneath buildings or in burrows that may open under occupied buildings.

Be aware of the signs of nontarget species inhabiting inactive ground squirrel burrows. Kit foxes will use an old burrow, enlarging the opening, often creating a keyhole-shaped entrance. Active pupping dens may be littered with prey remains, droppings, and matted vegetation, and show signs of fresh paw prints. The burrowing owl (*Athene cunicularia*) is another potential occupant of abandoned ground squirrel burrows. Only fumigate active ground squirrel burrows; county agricultural commissioners can provide additional information on how to recognize these. Do not treat a burrow if you suspect a nontarget animal is present.

Many county agricultural commissioners' offices sell USDA gas cartridges,

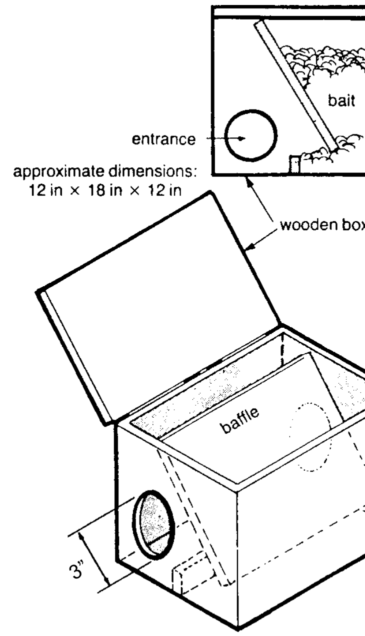

Figure 5. A bait box.

which are designed for fumigating burrowing rodents. Other types of fumigation cartridges are also available at retail outlets. Fumigation is most effective in spring or other times when soil moisture is high, which helps to contain the gas within the burrow system. Do not fumigate in summer or when the soil is dry because the gas more readily diffuses into small cracks present in dry soil. Do not fumigate during hibernation because the squirrel plugs its burrow with soil, preventing fumes from reaching the nest chamber. The plug cannot be seen by examining the burrow entrance.

Treat all active burrow systems when fumigating. When using a USDA gas cartridge, puncture the end with a nail or screwdriver at the points marked and rotate the nail to loosen the material inside. Insert the fuse into the center hole. Place the cartridge in the burrow as far as possible and light the fuse. With a shovel handle or stick, push the lighted cartridge down the burrow and quickly seal the opening with soil, tamping it down. Fill in connected burrows if smoke is seen escaping. Larger burrow systems usually require two or more cartridges placed in the same or connecting burrow openings. After 24 hours, check for reopened burrows and re-treat as needed.

Toxic Baits

Anticoagulant baits, available at county agricultural commissioners' offices, are recommended for controlling ground squirrels. To be effective, anticoagulants must be consumed in several feedings over a period of 5 or more days. These features, as well as an antidote (vitamin K_1), make anticoagulant baits relatively safe for humans and pets. Keep pets out of treated areas, check the areas daily, and remove and dispose of any carcasses. Dogs are more likely to consume the pelletized cereal-based baits than the loose grain baits. Pelletized baits are prohibited in kit fox areas.

Anticoagulant baits can be used in bait boxes or by repeated spot baiting. Bait boxes are small structures that the squirrel must enter to eat the bait. Boxes contain sufficient bait for repeated feedings. They are the preferred baiting method around homes and other areas where children, pets, and poultry are present.

Unless a bait label specifies otherwise, bait boxes can be constructed from any durable material and in a variety of designs. If you design a bait box, make the entrance hole(s) about 3 inches across to allow access to squirrels but not to larger animals (Fig. 5). Construct a lip to prevent bait from spilling out of the box when squirrels exit. Provide a lock on the box or devise some other method that will make it difficult for children to open. Secure the bait box so it cannot be turned over or easily removed. A self-feeding arrangement insures that the pest gets a continuous supply of bait. Never fill a bait box with more than 5 pounds of bait.

Place bait boxes near runways or burrows. If squirrels are present over a large area, space the boxes at 100- to 200-foot intervals. Initially, inspect bait stations daily and add bait as needed. Increase the amount of bait if all is eaten by the end of the day. Fresh bait is important; replace moldy or old bait. Do not use old, leftover bait. It may take a number of days before squirrels become accustomed to the bait box and enter it. Anticoagulant bait generally requires 2 to 4 weeks or more to be effective. Continue baiting until all feeding ceases and no squirrels are observed. While few ground squirrels will die aboveground, those that do should be picked up and disposed of as described in the section above on *Trapping* and in accordance with label directions. Also, pick up and dispose of unused bait (according to label instructions) upon completion of the control program.

Habitat Modification

Ground squirrels generally are found in open areas, although they sometimes use available cover. Remove brush piles and debris to make an area less desirable to ground squirrels. This also aids in detection of squirrels and their burrows, and improves access during control operations.

Ground squirrels can reinvade a site by moving into vacant burrows. Destroy old burrows by deep ripping them to a depth of at least 20 inches, using a tractor and ripping bar(s). Simply filling in the burrows with soil does not prevent reinvasion as ground squirrels easily find and reopen old burrows.

Other Control Techniques

Shooting squirrels with a .22 rifle may provide some control but is very time-consuming. Shooting is recommended only when it can be safely done in rural locations where squirrel numbers are very low. There are no effective frightening devices or repellents that will cause ground squirrels to leave their burrows or avoid an area or crop.

Natural Control

Many predators, including hawks, eagles, rattlesnakes, and coyotes, eat ground squirrels. In most cases, predators are not able to keep ground squirrel populations below the level at which they become pests for the home gardener. Dogs may prevent squirrels from entering small areas, but they cannot control established squirrel populations.

Follow-up

For those who live next to wildlands or other areas where squirrels are common, an ongoing control program will be necessary. Squirrels will reinvade over time. Once ground squirrels have been controlled, periodically monitor the area for reinfestation. Check for new burrows. Start control actions as soon as new squirrels are noticed. It is easier and less expensive to control a small population.

REFERENCES

California Department of Pesticide Regulation. 1995. *Protecting Endangered Species: Interim Measures for San Joaquin Kit Fox.* Sacramento: Pestic. Regis. Branch, Pestic. and Toxic Substances H-7506. 13 pp. For online information, see http://www.cdpr.ca.gov/docs/es/espdfs/sjkfall.pdf or http://www.cdpr.ca.gov/docs/es/espdfs/sjkfden.pdf

Clark, J. P. 1994. *Vertebrate Pest Control Handbook.* 4th ed. Sacramento: Div. Plant Industry, Calif. Dept. Food and Agric. 350 pp.

Marsh, R. E. 1994. Belding's, California, and rock ground squirrels. In S. E. Hygnstrom, R. M. Timm, and G. E. Larson, eds. *Prevention and Control of Wildlife Damage.* Vol. 1. Lincoln: Univ. Neb. Coop. Ext. pp. B.151–158.

Salmon, T. P. and R. E. Lickliter. 1984. *Wildlife Pest Control around Gardens and Homes.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 21385. 90 pp.

Tomich, P. Q. 1982. Ground squirrels. In J. A. Chapman and G. A. Feldhamer, eds. *Wild Mammals of North America: Biology, Management, and Economics.* Baltimore: Johns Hopkins Univ. Press. pp. 192–208.

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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CLIFF SWALLOWS

Integrated Pest Management Around the Home

Swallows, particularly cliff swallows, *Hirundo pyrrhonota* (Fig. 1), often live in close proximity to people. While enjoyable to watch, cliff swallows nesting in colonies on buildings and other structures can become a nuisance. Their droppings can foul machinery, create aesthetic problems, and cause potential health hazards by contaminating foodstuffs. Their mud nests eventually fall to the ground and can cause similar problems. In addition, swallow nests frequently contain mites and insects such as swallow bugs (*Oeciacus vicarius*); swallow bugs are related to bed bugs and will bite humans, although humans are not their usual host.

Seven members of the swallow family breed in California: the tree swallow (*Tachycineta bicolor*), violet-green swallow (*Tachycineta thalassina*), purple martin (*Progne subis*), bank swallow (*Riparia riparia*), rough-winged swallow (*Stelgidopteryx serripennis*), barn swallow (*Hirundo rustica*), and cliff swallow. The first three nest in cavities such as woodpecker holes or birdhouses. The bank and rough-winged swallows nest in natural crevices or burrows dug in earthen banks. Barn and cliff swallows build mud nests attached to buildings and other structures, a habit that sometimes puts them into conflict with people. This is particularly true of the cliff swallow—the swallow of San Juan Capistrano—which nests in large colonies of up to several hundred pairs. In contrast, barn swallows tend to nest as single pairs and, consequently, do not cause many problems.

BIOLOGY

Swallows feed on insects and spend a large part of each day in the air catching flies, beetles, and mosquitos. Their long, pointed wings give them great speed and maneuverability. Normally, swallows are not seen on the ground except when collecting mud for their nests. Most do not have musical voices but only twitter or squeak.

The cliff swallow is 5 to 6 inches in length and is the only square-tailed swallow in California. In contrast, the barn swallow is distinguished by its long, deeply-forked tail. The cliff swallow is also recognized by its pale, orange-brown rump, white forehead, dark rust-colored throat, and steel-blue crown and back.

Figure 1. Adult cliff swallow.

Distribution and Habitat

Cliff swallows are found throughout California, except in high mountains and the dry southeastern desert. Four basic conditions are found at all cliff swallow colonies: (1) an open habitat for foraging; (2) a vertical surface beneath an overhang for attaching the nest; (3) a supply of mud that has the proper consistency for nest building; and (4) a body of fresh water for drinking.

The original nesting sites of cliff swallows were cliffs and walls of canyons. Structures, such as buildings, bridges, and overpasses, and agricultural activities have increased the number and distribution of suitable nesting sites, and cliff swallow populations have increased accordingly. In general, wherever irrigation water and buildings or other structures are found, suitable breeding conditions may exist.

Cliff swallows spend the winter months in South America. In late winter and early spring, they begin a northward migration over land through Central America and Mexico. Arrival dates can vary greatly because of weather conditions. Usually by late February or early March, the first migrants appear in southern California. Two or three weeks later, cliff swallows begin arriving in northern California. Cliff swallows migrate during the day and catch flying insects enroute. Swallows will not penetrate regions unless flying insects are available for food, which usually occurs after a few days of relatively warm weather (70°F or more).

Site Selection

Cliff swallows arrive at nest colonies in successive waves. A definite homing tendency exists among adults that previously nested at a colony. These birds are the first to return, followed by adults who bred at other colonies in previous years and by young birds who have not yet bred. The younger birds include individuals not born at the selected colony.

In addition to their homing tendency, breeding swallows are attracted to old nests. Under suitable conditions, a nest is quite durable and can be used in successive years. Old nests are usually claimed on the first day of arrival, although probably not by the original makers. Dilapidated nests are quickly occupied and repaired.

Figure 2. A cliff swallow nest.

Nest Construction

Cliff swallow nests are gourd-shaped enclosed structures built of mud pellets, consisting primarily of sand with smaller amounts of silt and clay (Fig. 2). (In contrast, barn swallow nests are cup-shaped and the pellets contain coarse organic matter such as grass stems, horse hairs, and feathers.) The cliff swallow nest chamber is globular and extends forward into an entrance tunnel that opens downward. The tunnel may be absent from some nests. Nest dimensions vary from $5^1/_2$ to $10^1/_2$ inches in length and $5^1/_2$ to 8 inches in basal width, and the opening averages $1^3/_4$ inches in diameter. The nest is cemented with mud under the eave of a building, bridge, or other vertical surface. Usually the first nests are located at the highest point possible with subsequent nests attached below it, forming a dense cluster.

Both sexes construct the nest, proceeding slowly to allow the mud to dry and harden. Depending on mud supply and weather, nest construction takes 1 to 2 weeks. Mud is collected at ponds, puddles, ditches, and other sites up to $^1/_2$ mile away, with many birds using the same mud source. A typical nest contains 1,000 to 1,400 mud pellets, each representing one trip to and from the nest. Cliff swallows sometimes build two or three nests per season; not all nests are used, however.

Egg Laying

Egg laying usually begins before the nest is completely finished. Each day one egg is laid until the clutch of three to four eggs is completed. In central California, egg laying generally occurs between late April and the end of May. In southern California nesting can begin during late March and in the extreme northeastern part of the state as late as June. Within a colony the date of egg laying varies because of the staggered arrival dates of the birds.

Nest Failures

Renesting will occur if nests or eggs are destroyed. For example, nests may fall because they were built too rapidly or they may crumble because of prolonged humid weather. House sparrows (*Passer domesticus*) sometimes take over empty swallow nests and have been known to drive off swallows from new nests. A cliff swallow nest taken over by house sparrows is identified by the abundant nest lining (grasses, weeds, and feathers) protruding from the entrance.

Hatching and Feeding

Both sexes incubate the eggs, which hatch in 15 or 16 days. The adults are kept busy feeding the nestlings by foraging over an area sometimes 2 to 4 miles from the nest. Occasionally, long periods of continuous rainfall make it difficult for the adults to find food and they may abandon the nestlings. A sign of a successful nest is white excrement rimming the nest entrance, indicating the presence inside of young swallows.

Fledging and Post-nesting Period

In mid-May to mid-June, 20 to 25 days after hatching, the young birds fledge (take their first flight). They look similar to adults but are dull colored and have less sharply defined color patterns. The young will return to the nest for 2 to 3 days to be fed before leaving it permanently. They remain near the colony for about a week.

In California most cliff swallows raise one brood each year, although some may raise two. The time required from the start of nest building to departure after raising one brood is 47 to 64 days. Swallows are usually present at the colony for up to 100 days.

After leaving the nesting colony, cliff swallows will remain in the general area for several weeks. By mid-August there is a general southward movement, and by the end of September few swallows remain, except in southern California where a few linger into October.

MANAGEMENT

Actions to solve problems with swallows should be started as soon as they are identified. Cliff swallows are colonial and the number of nesting birds can increase significantly from year to year. They are best managed by nest removal and exclusion techniques. There are no chemical toxicants registered for cliff swallow control, and shooting, trapping, or harming swallows is not permitted.

Legal Status

All swallows are classified under the Migratory Bird Treaty Act of 1918 as migratory insectivorous birds and are protected by state and federal regulations. It is illegal for any person to take, possess, transport, sell, or purchase them or their parts, such as feathers, nests, or eggs, without a permit. As a result, certain activities affecting swallows are subject to legal restrictions.

Permit Requirements

Depending on your location, a depredation permit issued by the U.S. Fish and Wildlife Service may be required to remove cliff swallow nests. In the western administration region of the U.S. Fish and Wildlife Service, which includes California, a permit is not required to remove nests under construction that do not contain any new eggs or young, or nests abandoned after the breeding season. In other regions a permit may still be required for removing the above nests.

In all regions of the country, if new eggs or nestlings are present in the nests, a permit authorizing nest removal or the use of exclusion techniques is required. A permit will be issued only for very compelling concerns for human health and safety. Some examples are concerns for aircraft safety from a nesting colony at an airport or potential food contamination from a colony over a loading area at a food processing center. In most cases a permit for lethal control will not be issued for swallows nesting on a residence or other buildings causing aesthetic damage.

For all permit requirements, contact the main office of USDA-APHIS Wildlife Services in your state. In California the address is P.O. Box 255348, Sacramento, CA 95865-5348, phone (916) 979-2675.

You will be referred to a district biologist who will assess the problem and make control recommendations. If lethal control is recommended, then a permit application must be completed and sent to the U.S. Fish and Wildlife Service regional office along with a fee ($25 in 2000).

Timing is critical. It usually takes 10 to 14 days to obtain a permit so you must plan ahead if a problem is expected. It is not advisable to wait until nest building begins to apply for a permit, because swallows build their nests and lay eggs in a short time. Egg laying begins before nest contruction is completed; eggs may be present once the nest reaches the cup stage, at which point a permit usually will not be issued. For those regions that require a permit, if a swallow problem has been experienced in the past at a site and is expected to reoccur, then apply for a permit in advance of the birds' return.

Nest Removal

In areas where a permit is required, the nest removal method will be specified by the permit. In California, old nests or nests under construction may be washed down with water or knocked down with a pole. Swallows are strongly attracted to old nests or to the remnants of deteriorated nests, so all traces of mud should be removed. During nest building, nest removal will require many days because cliff swallows persistently rebuild nests for most of the breeding season. They usually return the following year and the whole process must be repeated.

Exclusion

Exclusion refers to any control method that denies physical access to the nest site area. Exclusion represents a relatively permanent, long-term solution to the problem. In California, a permit is not required for this method if it is done before the birds arrive, during nest building when there are no eggs or young in the nest, or after the birds have left for the winter. If swallows have eggs or young in the nest, exclusion may not be used without a permit.

Netting can provide a physical barrier between the birds and the nest site. The mesh size should be 1/2 to 3/4 inch; however, 1 inch has been used successfully. If a plastic net is used, it should be attached so that it can be pulled taut. This prevents flapping in the wind, which looks unsightly and results in tangles or breakage at mounting points. The net should not have any loose pockets or wrinkles that could trap and entangle birds.

Attach netting to buildings before the birds arrive and leave it up permanently or remove it after the nesting season (Fig. 3). Netting can be attached using tape, staples, or hooks on the eaves and the side of the building. An advantage of hooks is that the net can be taken down during the nonbreeding period or for maintenance of light fixtures, painting, etc. If staples are used, they should be rust-resistant to avoid unsightly rust stains on the building. For netting, a supporting framework of wooden dowels, wood laths, or metal rods along the edges will ease attachment to the hooks and create more even tension on the net. Netting may also be wrapped once or twice around wood laths and nailed directly to the building. The netting should extend from the outer edge of the eave down to the side of the building where the protection from the elements given by the eaves is lost (Fig. 4a). Be sure there are no openings in the net where swallows might enter.

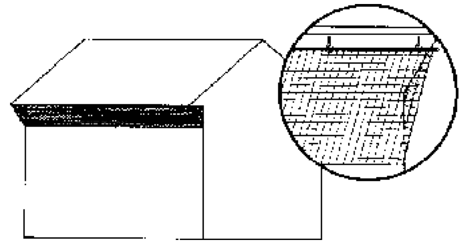

Figure 3. Mount netting from the outer edge of the eave down to the side of the building. Insert shows one possible method of attachment using hooks and wooden dowels.

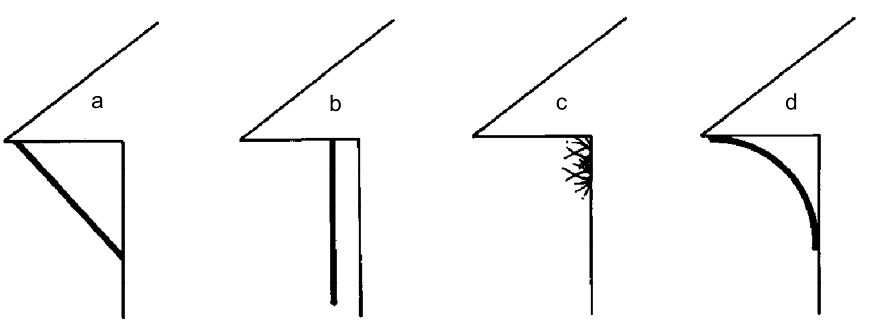

Figure 4. Four methods that may deter cliff swallow nesting: (a) netting attached from the outer edge of the eave down to the side of the building; (b) a curtain of netting; (c) metal projectors attached along the junction of the wall and eave; (d) fiberglass panel mounted to form a smooth, concave surface.

Some individuals have reported that hanging a curtain of netting from the eave will prevent nesting (Fig. 4b). The curtain should be 3 to 4 inches from the wall and extend down from the eave 18 inches or more.

Blocking the entrance will prevent cliff swallows from nesting inside buildings. Hang netting or strip doors of vinyl plastic or similar material across the entrance like curtains, allowing passage of vehicles, materials, or people (Fig. 5). Weighting the bottom of the netting will help keep it reasonably taut and in position during windy weather. Cliff swallows have been known to abandon nests inside a barn loft when the entrance was partially closed, reducing it to less than 8 x 8 feet.

Usually, swallows will not fly into a net but will stop and hover in front of it. If only that section of a building where swallows have nested is netted, the swallows will often choose alternative sites on the same structure. Therefore, any part of a building suitable for nesting must be netted. After the netting or wire mesh is installed, monitor the area for entry points and make necessary adjustments.

Other Methods

Nesting is sometimes discouraged through the use of metal projectors (Fig. 4c). These are sharp, needlelike wire or plastic devices generally installed along building ledges and windowsills to discourage birds from roosting (Fig. 6). This method is not always successful in preventing swallows from nesting. In one instance cliff

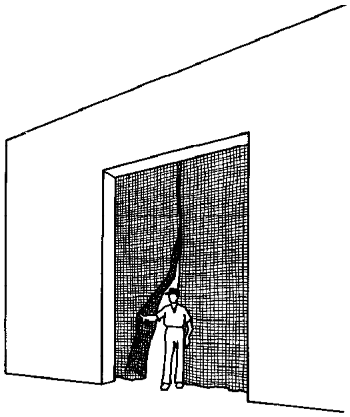

Figure 5. Netting hung like a curtain across a large entrance of a building.

swallows learned to land on the metal spines and eventually built nests attached to them. Attach the sharp projectors to cover the area where swallows prefer to build nests, especially horizontally along walls protected by eaves. Additional projectors running vertically should be attached along interior corners. Once installed, projectors are left in place permanently.

Fiberglass panels that are 6 inches wide have been used to prevent nesting in some situations (Fig. 4d). The panels are installed between the eave and wall forming a smooth, concave surface that makes nest attachment difficult.

Modification of the surface where swallow nests would be attached sometimes effectively discourages nesting. Swallows prefer rough, uneven surfaces that provide a good foothold and suitable surface for nest attachment. Removing the rough surface of the wall and overhang can make the site less attractive to swallows. Attaching glass, sheet metal, or other very smooth-surfaced materials to the potential nest site can inhibit swallow nesting. A fresh coat of paint producing a slick surface may discourage nesting. Removing old nests and painting the area may discourage nesting the following year.

Other methods have shown little success or are unproven against cliff swallows. These include employing hawk, owl, or snake models or using taped alarm calls, noisemakers, revolving lights, and chemical roost repellents.

Sources of Control Material

A partial list of sources of supply for netting and metal or plastic projectors is given below. Netting is also available at many hardware and farm supply stores.

NETTING

Bird Barrier America
20925 Chico St.
Carson, CA 90746
(800) 503-5444, (310) 527-8000;
fax (310) 527-8005
www.birdbarrier.com

Sutton Agricultural Enterprises, Inc.
746 Vertin Ave.
Salinas, CA 93901
(831) 422-9693; fax (831) 422-4201

Wildlife Control Technology, Inc.
2501 North Sunnyside Ave.
Fresno, CA 93727

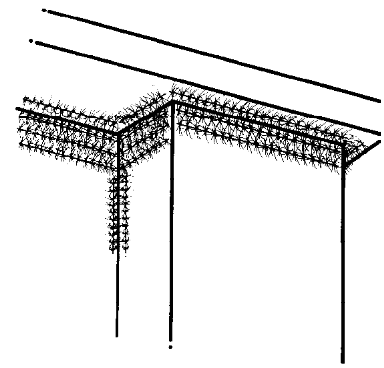

Figure 6. Mount metal projectors horizontally along walls protected by eaves and vertically along interior corners.

(800) 235-0262; fax (559) 490-2260
www.wildlife-control.com

METAL OR PLASTIC PROJECTORS

Bird-X, Inc.
300 North Elizabeth St.
Chicago, IL 60607
(800) 662-5021; fax (312) 648-0319
www.bird-x.com

Cat Claw, Inc.
Box 5250
Johnstown, PA 15904
(800) 832-2473; fax (800) 732-0380
www.catclaw.com

ECOPIC
725 S. Adams Rd., Suite 270
Birmingham, MI 48009
(313) 647-0505; fax (313) 647-7811

The Huge Company
7625 Page Boulevard
St. Louis, MO 63133
(314) 725-2555; fax (800) 873-4843

Nixalite Company of America
P.O. Box 727
East Moline, IL 61244-0727
(800) 624-1189; fax (309) 755-0077

For more information contact the University of California Cooperative Extension or agricultural commissionerÕs office in your county. See your phone book for addresses and phone numbers.

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WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

SECTION 8.3

IPM for Pigeons in Schools

Adapted from Material by W. Quarles,
Bio-Integral Resource Center

Pigeons not only make themselves a nuisance by their roosting and nesting activity and their noisy behavior, but they also carry and transmit a variety of human and avian diseases. Pigeons and their nests can also harbor a number of ectoparasites that are known to attack humans.

Pigeon droppings deface buildings and statues and their acidity can hasten the deterioration of these structures. Droppings can foul areas where people walk, sit, or work and in large amounts can kill vegetation and produce flies and objectionable odors. Droppings that accumulate on stairs, fire escapes, or other walking surfaces make these areas slippery and dangerous. Debris from pigeons and their nests can clog gutters, downspouts, and drains.

Pigeons are known to carry and transmit diseases to humans through their droppings, especially when the feces dry and particles become airborne. It is rare for health officials to specifically attribute disease outbreaks to flocks of pigeons. The potential for transmission however is real and should be taken seriously when these birds live in close proximity to humans. Diseases spread by pigeons include aspergillosis, candidiasis, cryptococcosis, encephalitis, histoplasmosis, Newcastle disease, ornithosis, salmonellosis, and toxoplasmosis.

Biology

Typically, the feral pigeon (Columba livia) has a gray body with a whitish rump, two black bars on the secondary wing feathers, a broad black band on the tail, and red feet. Color variations include brown, rust, mostly white, and blackish.

Pigeons are gregarious birds that flock together in groups of several hundred. They move about, feed, and fly together. Each feeding flock is associated with a particular food source, but the individuals in a feeding flock may disperse to other flocks that roost and loaf in different areas, some close to the food source and some distant. Roosting, nesting, and loafing (daytime resting) sites tend to be located in high, protected areas, such as building ledges and roofs, drain spouts, steeples, and other architectural details that provide suitable space. Being creatures of habit, pigeons routinely feed, nest, and roost in the same places.

In rural areas pigeons feed on grain and seeds such as corn, wheat, rye, barley, millet, sunflower seeds, and rape seeds. In urban areas, they scavenge for bread, garbage, fruits, greens, and weed seeds. Pigeons occasionally feed on insects and livestock manure. Like chickens, pigeons need grit in their crop to grind up their food.

Pigeons have several broods per year, and sometimes lay a new clutch of eggs in the nest before the fledglings are out. Although breeding continues year around, it peaks in spring and summer.

Detection and Monitoring

A detailed and accurate survey is necessary before you design a management plan. You will need to consider all the factors that affect the bird problem including public relations and local, state, and federal laws that impact management methods.

The survey process may be time consuming and labor intensive, but the effectiveness of your management plan will depend on it. You will need a pair of binoculars to scan trees, and the ledges, windowsills, and roof areas of tall buildings. All the information you gather must be written down on a monitoring form (see **Appendix K** for a sample form).

You may need to perform your survey over a number of days to understand the movements of the birds. Observe just before dawn, shortly thereafter, in the middle of the day, and again at dusk.

Public Relations

When birds are managed, it is important to remember that the "pest" might be regarded fondly by nature enthusiasts. Good public relations are an essential element in the success of a school IPM program, but particularly where birds are concerned. Describe the health hazards and point out the ecological relationship between pest birds and other urban pests. For instance, rats often feed on dead pigeons and on food left for pigeons.

Feral pigeons are not protected by federal or state statute. The taking of banded homing pigeons however, is a misdemeanor. There may be municipal restrictions on the methods used to take feral pigeons. Be sure to ask your local County Office of Agriculture about any local restrictions on pigeon management.

Management Options

A number of management options are available, including habitat modification, exclusion and physical controls.

Habitat Modification

Prohibiting Bird Feeding

No one should be allowed to feed pigeons on school grounds, and if possible, nearby. Other control measures will not be effective if people are providing birds with food. Birdseed mixes can spread weed seeds, and bread or other foods can attract rodents.

Sanitation

Proper sanitation will greatly reduce the attractiveness of an area to pigeons. If children eat lunch outside, it is particularly important to remove all spilled food promptly after lunch. Provide an adequate number of garbage cans, and train children to put garbage inside the can. Garbage cans on school grounds should have removable domed tops with vertical spring-loaded swinging doors. The cans should be emptied frequently enough to prevent the contents from impeding the closure of the lid. Periodically clean the lids and cans of food wastes.

Eliminating Water Sources

Determine where pigeons are drinking and deny them these sources. Repair outside water leaks, eliminate excessive landscape watering that leads to puddling, fix clogged gutters, and exclude pigeons from heating, ventilation, and air conditioning units (HVACs) that provide them with water. Water sources that cannot be eliminated can be treated with a detergent or light oil to make them unpalatable to pigeons.

Exclusion

With all exclusion devices, it is essential to treat each roosting, nesting, and loafing area on the building to completely exclude pigeons from the structure. Otherwise, pigeons will simply move to any untreated areas. None of the exclusion methods listed below will work in every situation. Pest management personnel must evaluate the problem to decide which method is most appropriate and cost-effective.

Close openings in buildings that allow pigeons access to indoor nesting sites. Block these openings with wood, metal, glass, Plexiglas, masonry, 1/4-inch rust proofed wire mesh, or plastic or nylon netting. Secure netting properly, making sure there are no gaps through which birds can squeeze.

Reduce prime outdoor nesting and roosting areas with netting, porcupine wire, piano wire, monofilament line, electrified wire, or by retrofitting ledges with 45º ramps.

Facility Design

Most pigeon problems on buildings occur because building designs create ideal habitats for these birds. When new buildings or major renovations are being planned, provide architects with information about the link between design elements and pigeon behavior. You might arrange a short tour of the school grounds to view pigeon problems.

Bird Netting

Areas where birds are roosting, loafing, or nesting can be permanently screened off with either metal or plastic bird netting with 1-inch mesh. U.V.-stabilized polypropylene netting is available that can last as long as 10 years. Be sure to close all gaps to keep pigeons from squeezing through.

Pointed Wires

Wire with sharp spikes projecting in all directions is fastened to a solid base that can be easily installed on windowsills, ledges, roof peaks, ornamental architecture, or on wherever pigeons prefer to alight. The sharp points prevent them from landing but do not seriously harm the birds. Proper spacing is essential so that pigeons cannot build nests between the rows of projections. Inspect porcupine wires periodically to make sure that enterprising birds have not covered them with the kind of debris that allows nesting or perching. While proper installation and occasional maintenance may be expensive, the advantages of permanent control can justify the cost.

Large areas such as storage tanks, air conditioning units and wide ledges can be protected by a device made of long, spring-loaded and weighted wires that extend from a fixed base in all directions over the area. The wires move and bounce in the wind, preventing pigeons from roosting or nesting.

Piano-type Wire, Monofilament Line

Protect narrow beams, roof edges, cables, and pipes by installing a tightly stretched 16 to 18 gauge wire or 80-lb. test monofilament line one to two inches above the surface. This wire interferes with bird perching and take off. Attach "L" brackets to each end of the area above which the wire will be suspended, string the wire across, and take out the slack with turnbuckles. Weld the brackets to the surface or attach them with cable clamps or aircraft hose clamps. Do not use radiator clamps because they frequently become stripped under the high torque load.

Electrified Wires

These wires can be used on rooftops and other areas where people will not encounter them. Electrified wires are an expensive, but permanent exclusion device. They require somewhat more maintenance because accumulations of dirt, sticks, leaves, and other debris can cause shorts. These devices are similar to electric fences used for deer and other animals and work by delivering a shock that repels pigeons but doesn't kill them.

45º Angle Ramps

Pigeons cannot land or roost on surfaces with a 45º or steeper angle. Use sheet metal, concrete, stone, wood, Styrofoam blocks, or other materials to retrofit ledges with a ramp of the desired angle. It is important that the surface of the ramp be fairly smooth. If the surface is rough enough, pigeons can occupy even steeply pitched areas.

Frightening Devices

There are numerous devices on the market for frightening birds, ranging from small cannons to rubber snakes. None of these is effective against pigeons.

Physical Controls

Nest Removal

This technique should be used in conjunction with other control methods. Persistent removal of nests every 14 days may be necessary, and if the area is not modified to exclude pigeons, they will continue to rebuild their nests. Use a long pole to knock nests from ledges. Clean up debris with a heavy-duty vacuum with a HEPA filter.

Since pigeon nests may harbor ectoparasites, and pigeon droppings can transmit diseases, pest management personnel should wear protective clothing when removing nests. This clothing includes coveralls, a hood or hat, respirator, goggles, and gloves. Wear boots and tape the legs of the coveralls around them. Tape sleeves to gloves. Clothing can be sprayed with an insect repellent as an extra precaution.

Sticky Repellents

These sticky, non-toxic pastes and gels can be applied to ledges or other roosting areas to prevent birds from landing. Clean all surfaces to be treated, and if the surface is a porous one, such as stone, concrete, brick, or wood, apply a liquid sealer or strips of impervious tape so the repellent will not be absorbed. All potential roosting areas must be treated, otherwise birds will move to untreated areas.

Apply repellents with a caulking gun, or with a sprayer or paintbrush if you are using a thinner liquid formulation. Apply in one-half-inch strips no more than three inches apart, so birds will be repelled without becoming entangled.

Dirt and debris will foul repellents so they must be re-applied each year. In very dusty areas, you may have to renew them more often. Heavy gel formulations tend to last longer than the thinner, spray-on formulations.

Sticky repellents can melt and run down the sides of buildings in hot weather, and can harden and become ineffective in cold weather. Creative pigeons will sometimes drop debris on the gels and nest anyway.

Trapping

A nationwide survey of 464 wildlife or pest management specialists including Agricultural Commissioners and Cooperative Extension Agents showed that 83% of respondents rated trapping as a "moderate to excellent" control for pigeons (Gorenzel et al., 2000). As with any kind of trapping, experienced personnel will have greater luck than novices.

The bob-type trap is perhaps the most effective (see **Figure 8.3-1** [trap plans]). Available in several sizes, the bob-type trap works by luring pigeons through a one-way swinging door into an entrance scattered with grain.

To accustom the birds to the trap, scatter bait around and in the trap tying the bobs up and out of position. Use cracked corn, wheat, milo, oat groats, millet, popcorn, sunflower seeds, peas, bread, or peanuts. Leave the trap open until the birds have no fear of walking in to eat the bait, then release the bobs to put the trap into operation.

Placing live decoy pigeons inside the trap, as well as food, water, and shade, will improve trap effectiveness. Be sure to treat birds in traps humanely. The California Penal Code Section 597 states that failure to provide animals with "proper food, drink, or shelter or protection from the weather is a punishable offense." Check traps at least every other day. Leave no more than one to five decoy birds in the trap because too much activity in the trap may decrease catches. If you catch racing pigeons (they will have a leg band), release them or hold them for their owners.

Place traps where pigeons regularly roost, use a number of traps, and move them if you fail to catch birds.

Birds removed from traps should be killed, because even if they are released a great distance from the site, their homing abilities will ensure that they return. Pigeons can be euthanized by cervical dislocation. Activities such as these should not be conducted while children are at school.

Biological Controls

Birds of prey, such as falcons and hawks, have been established in some cities and National Park facilities to aid in pigeon control, but the public has usually objected strongly to observing raptors capturing pigeons. Natural predation from birds of prey will not provide satisfactory pigeon control.

Chemical Controls

If non-chemical methods alone prove insufficient to solve the problem, then integrating a pesticide into your management program may be warranted. Consult your local county office of the University of California Cooperative Extension for advice about the use of particular chemicals. They specialize in helping people with questions about pest problems. You can find your county office in the phone book or online at http://danr.ucop.edu/regional.htm. You can search for specific registered products in the DPR product and label database at http://www.cdpr.ca.gov/

Pesticides must be used in accordance with their U.S. EPA-approved label directions. Applicators of restricted use materials must be certified to apply pesticides. Pesticide applicators should always wear protective gear during applications. All labels and Material Safety Data Sheets (MSDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials when buildings are occupied, and never apply them where they might wash into the sanitary sewer or into outside storm drains.

When pesticides are needed, they should be applied in bait form. A pesticide product deployed in the form of a self-contained bait or trap, to gel or paste deployed as a crack and crevice treatment is exempt from the posting and notification requirements of the Healthy Schools Act.

There are three types of chemical control agents for pigeons: chemosterilants for birth control, psychochemical frightening agents, and avicides (chemicals used to kill birds). None of these chemical agents is recommended because the use of habitat modification, sanitation, exclusion, and trapping alone have been proven highly effective by many pest control operators around the country.

Bibliography

Albrecht, A. and P. Kampfer. 2001. [Microbial endangering of workers by feces of pigeons.] Gefahr. Reinhaltung Luft 61(3):91-99. [CAB Abstracts]

Baker, R.O. and A.C. Crabb. 1998. Proceedings of the 18th Vertebrate Pest Control Conference. University of California, Davis, CA.

Barclay, R.M.R. 1988. Variation in the costs, benefits, and frequency of nest reuse by barn swallows (Hirundo rustica). Auk 105:53-60.

Bennett, G.W., J.M. Owens and R.M. Corrigan. 1988. Urban pest birds. In: Truman's Scientific Guide to Pest Control Operations, 4th ed. Purdue University, Edgell Communications, Duluth, MN. 333-351 of 495 pp.

Booth, T.W. 1983. Bird dispersal techniques. In: Timm, pp. E1-E5.

Brown, V., H.G. Weston and J. Buzzell. 1973. Handbook of California Birds, 2nd ed. Naturegraph, Healdsburg, CA. 224 pp.

Brown, C.R. and M.B. Brown. 1986. Ectoparasitism as a cost of coloniality in cliff swallows (Hirundo pyrrhonota). Ecology 67(5): 1206-1218.

Corrigan, R.M. 1989. A guide to managing pigeons and sparrows. Pest Control Technology 17(1):38-40, 44, 46, 48, 50.

Crabb, A.C. and R.E. Marsh. 1988. Proceedings of the 13th Vertebrate Pest Conference. University of California, Davis, CA.

Daar, S., Drlik, T., Olkowski, H., and Olkowski, W. 1997. IPM for Schools: a How-To Manual. Bio-Integral Resource Center, Berkeley, CA. 215 pp.

Davis, L.R. and R.E. Marsh, eds. 1990. Proceedings of the 14th Vertebrate Pest Conference. University of California, Davis, CA.

Dautel, H. and W. Knulle. 1998. Seasonal oviposition and temperature requirements of eggs may limit northern distribution of European Argus reflexus (Acari: Argasidae). J. Med. Entomol. 35(1):26-37.

Emlen, J.T. 1952. Social behavior in nesting cliff swallows. Condor 54(4):177-199.

Emlen, J.T. 1954. Territory, nest building and pair formation in the cliff swallow. Auk 71:16-35.

Erskine, A.J. 1979. Man's influence on potential nesting sites and populations of swallows in Canada. Can. Field Naturalist 93(4):371-377.

Goodwin, D. 1967. Pigeons and doves of the world. Trustees of the British Museum (Natural History), London 1967:58-60.

Gorenzel, W.P. and T.P. Salmon. 1994. Swallows. In: Hyngstrom et al., pp. E121-E127.

Gorenzel, W.P., T.P. Salmon and A.C. Crabb. 2000. A national review of the status of trapping for bird control. In: Salmon and Crabb, pp. 5-21.

Haag-Wackenagel, D. 1993. Street pigeons in Basel. Nature 361:200.

Hyngstrom, S.E., R.M. Timm and G.E. Larson. 1994. Prevention and Control of Wildlife Damage, 2nd ed. USDA/APHIS, Great Plains Agricultural Council, University of Nebraska Cooperative Extension, Lincoln, NE.

Inglis, I.R. 1980. Visual bird scarers: an ethological approach. In: Wright and Inglis, pp. 121-143.

Johnston, R.F. and M. Janiga. 1995. Feral Pigeons. Oxford University Press, New York. 320 pp.

Kautz, E.J. and R.A. Malecki. 1990. Effects of harvest on final rock dove survival, nest success, and population size. U.S. Dept. Int. Fish and Wildl. Tech. Rep. 31:1-16.

Mallis, A. 1997. Handbook of Pest Control, 8th ed. S. Hedges, ed. Mallis Handbook and Technical Training Co., Cleveland, OH.

Mayhew, W.W. 1958. The biology of the cliff swallow in California. Condor 60(1):7-37.

Moller, A.P. 1990. Effects of parasitism by a haematophagous mite on reproduction in the barn swallow. Ecology 71(6):2345-2357.

Murton, R.K. 1968. Some predator-prey relationships in bird damage and population control. In: Murton and Wright, pp. 157-169.

Murton, R.K. and E.N. Wright. 1968. The Problem of Birds as Pests. Academic Press, New York. 254 pp.

Murton, R.K., R.J.P. Thearle and J. Thompson. 1972a. Ecological studies of the feral pigeon, Columba livia var. I. Population, breeding biology, and methods of control. J. Appl. Ecol. 9:835-874.

Murton, R.K., C.F.B. Coombs and R.J.P. Thearle. 1972b. Ecological studies of the feral pigeon Columba livia var. II. Flock behaviour and social organization. J. Appl. Ecol. 9:835-874.

Newton, I. 1998. Population Limitation in Birds. Academic, New York. 597 pp.

Pikula, J., M. Beklová and V. Kubik. 1982. The nidobiology of feral Columba livia f. domestica. Acta Sci. Nat. Acad. Brno 16(4):1-44.

Pinto, L.J. and G.W. Rambo. 1982. Bird Management Manual. National Pest Control Association, Dunn Loring, VA.

Pochop, P.A., R.J. Johnson, D.A. Aguero and K.M. Eskridge. 1990. The status of lines in bird damage control-a review. In: Davis and Marsh, pp. 317-324.

Redmond, J. 1984. IPM for rats: a case history. IPM Practitioner 6(3):2-3.

Quarles, W. 2000. West Nile encephalitis-again. Common Sense Pest Control Quarterly 16(3):4-5.

Salmon, T.P. and A.C. Crabb. 2000. Proceedings of the 19th Vertebrate Pest Conference. Unversity of California, Davis, CA. 456 pp.

Slater, A.J. 1998. Twenty-five years of managing birds associated with buildings at the University of California, Berkeley. In: Baker and Crabb, pp. 315-318.

Speich, S.M., H.L. Jones and E.M. Benedict. 1986. Review of the natural nesting of the barn swallow in North America. Am. Midland Naturalist 115(2):248-254.

Timm, R., ed. 1983. Prevention and Control of Wildlife Damage, 1st ed. Great Plains Agricultural Council/Nebraska Cooperative Extension/ University of Nebraska, Lincoln, Nebraska.

Timm, R.M. and R.E. Marsh. 1997. Vertebrate pests. In: Mallis, pp. 955-1019 of 1453 pp.

Turner, A. 1989. A Handbook of Swallows and Martins of the World. Christopher Helm, London. 258 pp.

Vogt, P.F. 2000. Effective dispersal of birds from buildings and structures by fogging with Rejex-it TP-40. In: Salmon and Crabb, pp. 77-80.

Weber, W.J. 1979. Health Hazards from Pigeons, Starlings and English Sparrows. Thomson Publications, Fresno, CA. 138 pp.

Williams, D.E. and R.M. Corrigan. 1994. Pigeons (rock doves). In: Hyngstrom et al., pp. E87-E96.

Woronecki, P.P. 1988. Effect of ultrasonic, visual, and sonic devices on pigeon numbers in a vacant building. In: Crabb and Marsh, pp. 266-272.

Wright, E.N. and I.R. Inglis. 1980. Bird Problems in Agriculture. British Crop Protection Council, Croydon, UK. 212 pp.

POCKET GOPHERS

Integrated Pest Management for Home Gardeners and Landscape Professionals

Pocket gophers (*Thomomys* spp.) are burrowing rodents that get their name from the fur-lined external cheek pouches, or pockets, that they use for carrying food and nesting materials. They are well equipped for a digging, tunneling lifestyle with powerfully built forequarters, large-clawed front paws, fine short fur that doesn't cake in wet soils, small eyes and small external ears, and highly sensitive facial whiskers to assist movements in the dark. An unusual adaptation is the gopher's lips, which can be closed behind the four large incisor teeth to keep dirt out of its mouth when it is using its teeth for digging.

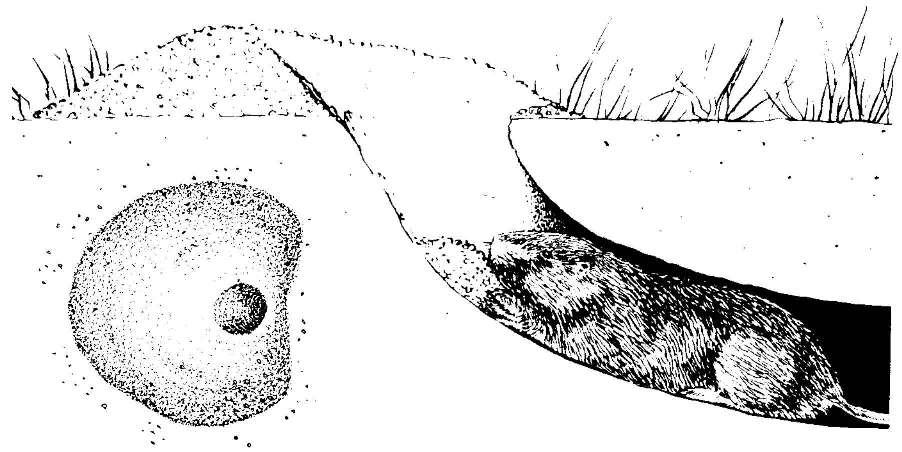

Figure 1. Top and side views of an unplugged pocket gopher mound.

IDENTIFICATION

Five species of pocket gophers are found in California, with Botta's pocket gopher (*Thomomys bottae*) being most widespread. Depending on the species, they may range in length from 6 to 10 inches. Although they are sometimes seen feeding at the edge of an open burrow, pushing dirt out of a burrow, or moving to a new area, gophers for the most part remain underground in the burrow system.

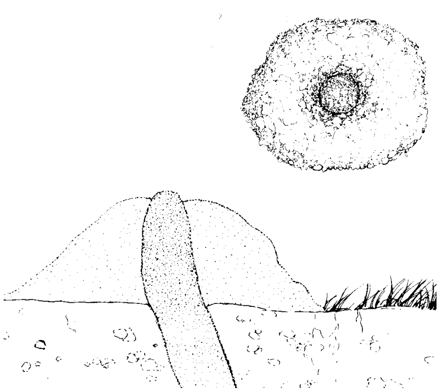

Figure 2. Top and side views of a mole mound.

Mounds of fresh soil are the best sign of gopher presence. Mounds are formed as the gopher digs its tunnel and pushes the loose dirt to the surface. Typically mounds are crescent- or horseshoe-shaped when viewed from above (Fig. 1). The hole, which is off to one side of the mound, is usually plugged. Mole mounds (Fig. 2) are sometimes mistaken for gopher mounds. Mole mounds, however, appear circular and have a plug in the middle that may not be distinct; in profile they are volcano-shaped. Unlike gophers, moles commonly burrow just beneath the surface, leaving a raised ridge to mark their path.

One gopher may create several mounds in a day. In nonirrigated areas, mound building is most pronounced during spring or fall when the soil is moist and easy to dig. In irrigated areas such as lawns, flower beds, and gardens, digging conditions are usually optimal year round and mounds can appear at any time. In snowy regions, gophers create burrows in the snow, resulting in long, earthen cores on the surface when the snow melts.

BIOLOGY AND BEHAVIOR

Pocket gophers live in a burrow system that can cover an area of 200 to 2,000 square feet. The burrows are about 2½ to 3½ inches in diameter; feeding burrows are usually 6 to 12 inches below ground, whereas the nest and food storage chamber may be as deep as 6 feet. Gophers seal the openings to the burrow system with earthen plugs. Short, sloping lateral tunnels connect the main burrow system to the surface and are created during construction of the main tunnel for pushing dirt to the surface.

Gophers do not hibernate and are active year-round, although fresh mounding may not be seen. They also can be active at all hours of the day. Gophers usually live alone within their burrow system, except for females with young or when breeding, and may occur in densities of up to 16 to 20 per acre.

Gophers reach sexual maturity at about 1 year of age and can live up to 3 years. Females produce one to three litters per year. In nonirrigated areas, breeding usually occurs in late winter and early spring, resulting in one litter per year, whereas in irrigated sites, up to three litters per year may be produced. Litters usually average five to six young.

Pocket gophers are herbivorous, feeding on a wide variety of vegetation, but generally preferring herbaceous plants, shrubs, and trees. Gophers use their sense of smell to locate food. Most commonly they feed on roots and fleshy portions of plants they encounter while digging. However, sometimes they feed aboveground, venturing only a body length or so from their tunnel opening. Burrow openings used in this manner are called "feed holes." They are identified by the absence of a dirt mound and a circular band of clipped vegetation around the hole. Gophers will also pull entire plants into their tunnel from below. In snow-covered regions gophers may feed on bark several feet up a tree by burrowing through the snow.

DAMAGE

Pocket gophers often invade yards and gardens, and feed on many garden crops, ornamental plants, vines, shrubs, and trees. A single gopher moving down a garden row can inflict considerable damage in a very short time. Gophers also gnaw and damage plastic water lines and lawn sprinkler systems. Their tunnels can divert and carry off irrigation water and lead to soil erosion. Mounds on lawns interfere with mowing equipment and ruin the aesthetics of well-kept turfgrass.

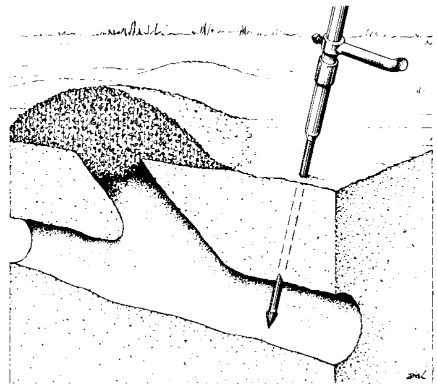

Figure 3. A gopher probe.

LEGAL STATUS

Pocket gophers are classified as nongame mammals by the California Fish and Game Code. This means that if they are found to be injuring growing crops or other property, including garden and landscape plants, they may be controlled at any time and in any legal manner by the owner or tenant of the premises.

MANAGEMENT

To successfully control gophers, the sooner you detect their presence and take control measures, the better. Most people control gophers in lawns, gardens, or small orchards by trapping and/or by using poison baits.

Probing for Burrows

Successful trapping or baiting depends on accurately locating the gopher's main burrow. To locate the burrow, you need to use a gopher probe (Fig. 3). Probes are commercially available or can be constructed from a pipe and metal rod. An enlarged tip that is wider than the shaft of the probe is an important design feature that increases the ease of locating burrows. Probes made from dowels or sticks may work in soft soil, but are difficult to use in hard or dry soils.

First, locate areas of recent gopher activity based on fresh mounds with dark, moist soil. Fresh mounds that are visible aboveground are the plugged openings of lateral tunnels. The main burrow can be found by probing about 8 to 12 inches from the plug side of the mound (i.e., to the right of the mound in Fig. 1); it is usually located 6 to 12 inches deep. When the probe penetrates the gopher's burrow, there will be a sudden, noticeable drop of about 2 inches. You may have to probe repeatedly to locate the gopher's main burrow, but your skill will improve with experience. Because lateral tunnels may not be revisited by the gopher, trapping and baiting in them is not as successful as in the main burrow.

Trapping

Trapping is a safe and effective method to control pocket gophers. Several types and brands of gopher traps are available. The most commonly used is a two-pronged pincher trap, such as the Macabee trap (Fig. 4), which is triggered when the gopher pushes

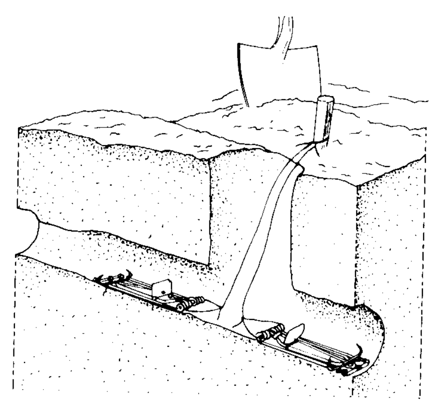

Figure 4. Macabee traps.

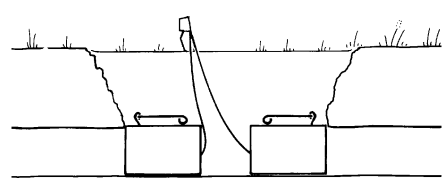

Figure 5. When putting box traps in place, cut the face of the hole smooth so that the traps can be pushed tightly against the tunnels. Cover the traps completely with about 1 inch of soil.

against a flat vertical pan. Another popular trap is the choker-style box trap.

To set traps, locate the main tunnel with a probe, as previously described. Use a shovel or garden trowel to open the tunnel wide enough to set traps in pairs facing opposite directions (Figs. 4 and 5). By placing traps with their openings facing in opposite directions, a gopher coming from either end of the burrow can be intercepted. The box trap is easier to use if you've never set gopher traps before, but setting it requires more excavation than if you are using the Macabee trap, an important consideration in lawns and some gardens. Box traps are especially useful when the diameter of the gopher's main burrow is small (less than 3 inches) because to use the Macabee-type wire traps, small burrows must be enlarged to accommodate them.

It is not necessary to bait a gopher trap, although some claim baiting gives better results. Lettuce, carrots, apples, or alfalfa greens can be used as bait. Place the bait at the back of a box trap behind the wire trigger or behind the flat pan of a Macabee-type trap. Wire your traps to stakes so they can be easily retrieved from the burrow, as shown in Figures 4 and 5. After setting the traps, exclude light from the burrow by covering the opening with dirt clods, sod, cardboard, or some other material. Fine soil can be sifted around the edges to ensure a light-tight seal. If too much light enters, the gopher may plug the burrow with soil, filling the traps and making them ineffective. Check traps often and reset them when necessary. If a gopher is not caught within 3 days, reset the traps in a different location.

Baiting with Toxic Baits

The key to an effective toxic baiting program is bait placement. Always place pocket gopher bait in the main underground tunnel, not the lateral tunnels. After locating the main gopher burrow with a probe, enlarge the opening by rotating the probe or inserting a larger rod or stick. Following label directions, place the bait carefully in the opening using a spoon or other suitable implement that is used only for that purpose, taking care not to spill any on the ground surface. A funnel is useful for preventing spillage.

Strychnine-treated grain bait is the most common type used for pocket gopher control. This bait generally contains 0.5% strychnine and is lethal with a single feeding. Baits containing anticoagulants are also available. When using anticoagulant baits, a large amount of bait (about 10 times the amount needed when using strychnine baits) is required so that it is available for multiple feedings. Although generally less effective than strychnine baits, anticoagulant baits are preferred for use in areas where children and pets may be present. When using either type of bait, be sure to follow all label directions and precautions.

After placing the bait in the main burrow, close the probe hole with sod, rocks, or some other material to exclude light and prevent dirt from falling on the bait. Several bait placements within a burrow system will increase success. Tamp down existing mounds so you can distinguish new activity. If new mounds appear for more than 2 days after strychnine baiting or 7 to 10 days after anticoagulant baits have been used, you will need to rebait or try trapping.

If a large area is infested with gophers, a hand-held bait applicator will speed treatment. Bait applicators are a combination probe and bait reservoir. Once a burrow is located using the probe, a trigger releases a measured amount of bait into the tunnel. Generally, strychnine bait is used with such a bait applicator because the applicator dispenses only a small quantity of bait at a time.

Exclusion

Underground fencing might be justified for valuable ornamental shrubs or landscape trees. To protect existing plantings, bury hardware cloth or ¾-inch mesh poultry wire 2 feet deep and extended at least 1 foot aboveground to deter gophers moving overland. This method is less than perfect, however, because gophers may burrow below the wire; also, the wire may restrict and damage root growth of trees. Small areas such as flower beds may be protected by complete underground screening of sides and bottoms. When constructing raised vegetable or flower beds, underlay the soil with wire to exclude gophers. Wire baskets to protect individual plants can be made at home or are commercially available and should be installed at the time of planting. If you use wire, use light-gauge wire for shrubs and trees that will need protection only while young. Leave enough room to allow for the roots to grow. Galvanized wire provides the longest lasting protection.

Six to 8 inches of coarse gravel 1 inch or more in diameter around underground sprinkler lines or utility cables may deter gophers.

Natural Controls

Because no population will increase indefinitely, one alternative to a gopher problem is to do nothing, letting the population limit itself. Experience has shown, however, that by the time gopher populations level off naturally, much damage has already been done around homes and gardens.

Predators, including owls, snakes, cats, dogs, and coyotes, eat pocket gophers. Predators rarely, however, remove every prey animal, but instead move on to hunt at more profitable locations. In addition, gophers have defenses against predators. For example, they can escape snakes in their burrows by rapidly pushing up an earthen plug to block the snake's advance.

The idea of attracting barn owls to an area for gopher control by installing nest boxes has been explored. Although barn owls prey on gophers, their habit of hunting over large areas, often far from their nest boxes, and their tendency to hunt areas with abundant prey, make them unreliable for gopher control. When a single gopher, which is capable of causing damage rapidly, invades a yard or garden, a gardener cannot afford to wait for an owl to arrive. Effective action, usually trapping or baiting, must be taken immediately.

Habitat Modification

Reduction of gopher food sources using either chemical or mechanical methods may decrease immigration of gophers. If feasible, remove weedy areas adjacent to yards and gardens to create a buffer strip of unsuitable habitat.

Other Control Methods

Pocket gophers can easily withstand normal garden or home landscape irrigation, but flooding can sometimes be used to force them from their burrows where they can be dispatched with a shovel or caught by a dog. Fumigation with smoke or gas cartridges is usually not effective because gophers quickly seal off their burrow when they detect smoke or gas. But if you are persistent with and use repeated treatments, some success may be achieved.

No repellents currently available will successfully protect gardens or other plantings from pocket gophers. Plants such as gopher purge *(Euphorbia lathyrus)*, castor bean (*Ricinus communis*), and garlic have been suggested as repellents but these claims have not been substantiated by research. Although there are many frightening devices commercially available to use on pocket gophers (vibrating stakes, ultrasonic devices, wind-powered pinwheels, etc.), pocket gophers do not frighten easily, probably because of their repeated exposure to noise and vibrations from sprinklers, lawnmowers, vehicles, and people moving about. Consequently, frightening devices have not proven to be effective. Another ineffective control method is placing chewing gum or laxatives in burrows in hopes of killing gophers.

Follow-up

Once pocket gophers have been controlled, monitor the area on a regular basis for reinfestation of the land. Level all existing mounds after the control program and clean away weeds and garden debris so fresh mounds can be seen easily. It is important to check regularly for reinfestation because pocket gophers may move in from other areas and damage can reoccur within a short time. If your property borders wildlands, vacant lots, or other areas that serve as a source of gophers, you can expect gophers to reinvade regularly. Be prepared to take immediate control action when they do; it is easier, cheaper, and less time-consuming to control one or two gophers than to wait until the population builds up to the point where the gophers are causing excessive damage.

REFERENCES

Case, R. M., and B. A. Jasch. 1994. Pocket gophers. In S. E. Hygnstrom, R. M. Timm, and G. E. Larson, eds. *Prevention and Control of Wildlife Damage*. Vol. 1. Lincoln: Univ. Neb. Coop. Ext. pp. B.17–29.

Chase, J. D., W. E. Howard, and J. T. Roseberry. 1982. Pocket gophers. In J. A. Chapman and G. A. Feldhamer, eds. *Wild Mammals of North America*. Baltimore: Johns Hopkins Univ. Press. pp. 239-255.

Ingles, L. G. 1965. *Mammals of the Pacific States*: *California, Oregon, Washington.* Stanford: Stanford Univ. Press. 506 pp.

Salmon, T. P., and R. E. Lickliter. 1984. *Wildlife Pest Control around Gardens and Homes*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 21385. 90 pp.

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

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WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

VOLES (MEADOW MICE)

Integrated Pest Management for Home Gardeners and Landscape Professionals

Six species of voles of the genus *Microtus* occur in California. They are collectively called meadow mice or voles. Two species of voles are responsible for the majority of damage. The California vole (*Microtus californicus*) is the most widespread vole in the state, found in the Owens and Central valleys and nearly the entire length of the coast range. The montane vole (*M. montanus*) inhabits northeastern California and the eastern Sierra slope. Voles do not commonly invade homes, and should not be confused with the house mouse, *Mus musculus*.

Voles are intriguing small mammals because some populations regularly go through cycles from low to high numbers with occasional irruptions that can send numbers soaring (up to several thousand per acre).

IDENTIFICATION

Voles are mouselike rodents somewhat similar in appearance to pocket gophers (Fig. 1). They have a compact, heavy body, short legs, short-furred tail, small eyes, and partially hidden ears. The long, coarse fur is blackish brown to grayish brown. When fully grown they can measure 5 to 8 inches long, including the tail.

Although voles do spend considerable time aboveground and may occasionally be seen scurrying about, most of their time is spent below ground in their burrow system. The clearest signs of their presence are the well-traveled, aboveground runways that connect burrow openings (Fig. 2); the runways are usually hidden beneath a protective layer of grass or other ground cover. The maze of runways leads to multiple burrow openings that are each about 1½ to 2 inches in diameter. The runways are easily found by pulling back overhanging ground cover. Fresh clippings of green grass and greenish-colored droppings about 3/16 inch long in the runways and near the burrows are further evidence of voles. With age, the droppings lose the green coloring and turn brown or gray.

BIOLOGY AND BEHAVIOR

Voles are active day and night, yearround. They are normally found in areas with dense vegetation. Voles dig many short, shallow burrows and make underground nests of grass, stems, and leaves. In areas with winter snow, voles will burrow in and through the snow to the surface.

Several adults and young may occupy a burrow system. Home-range size varies with habitat quality, food supply, and population levels, but in most cases it is no more than a few hundred square feet.

Vole numbers fluctuate from year to year; under favorable conditions their populations can increase rapidly. In some areas their numbers are cyclical, reaching peak numbers every 3 to 6 years before dropping back to low levels. Voles may breed any time of year, but the peak breeding period is spring. Voles are extremely prolific with females maturing in 35 to 40 days and having five to ten litters per year. Litter size ranges from three to six. However, voles seldom live past 12 months of age.

Voles are mostly herbivorous, feeding on a variety of grasses, herbaceous plants, bulbs, and tubers. They eat bark and roots of trees, usually in fall or winter. Voles store seeds and other plant matter in underground chambers.

Voles are poor climbers and do not usually enter homes or other buildings. Instead, they inhabit wildlands or croplands adjacent to buildings, or gardens and landscaped sites with protective ground cover. Most problems around homes and gardens occur during outbreaks of vole populations.

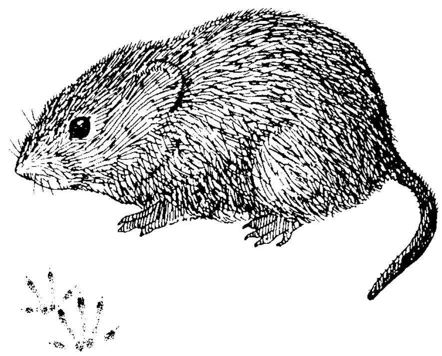

Figure 1. Meadow mouse.

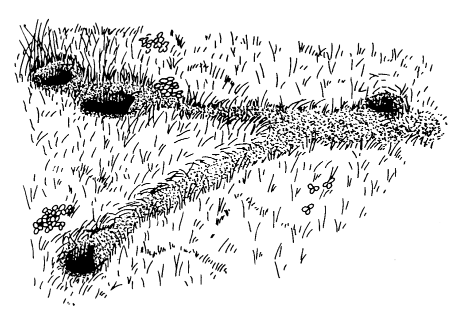

Figure 2. Runways, burrows.

DAMAGE

Voles cause damage by feeding on a wide range of garden plants including artichoke, beet, Brussels sprouts, cabbage, carrot, cauliflower, celery, lettuce, turnip, sweet potato, spinach, and tomato. Turf and other landscape plantings such as lilies and dichondra may be damaged. Voles will gnaw the bark of fruit trees including almond, apple, avocado, cherry, citrus, and olive. Vole damage to tree trunks normally occurs from a few inches aboveground to a few inches below ground. If the damage is below ground, you will need to remove soil from the base of the tree to see it. Although voles are poor climbers, if they can climb on to low-hanging branches they may cause damage higher up on trees as well.

Gnaw marks about ⅛ inch wide and ⅜ inch long found in irregular patches and at various angles, taken in conjunction with other signs (droppings, runways, and burrows), indicate vole damage. If voles gnaw completely around the trunk or roots, the tree's flow of nutrients and water will be disrupted; this is called girdling. Girdling damage on trunks and roots can kill trees. Signs of partial trunk or root girdling may include a prolonged time before young trees bear fruit, reduced fruit yield, abnormal yellowish leaf color, and overall poor vigor. Where snow cover is present, damage to trees may extend a foot or more up the trunk. Damage that occurs under snow cover often escapes notice until it is too late.

LEGAL STATUS

Voles are classified as nongame mammals by the California Fish and Game Code. Nongame mammals injuring or threatening growing crops or other property may be controlled at any time and in any legal manner by the owner or tenant of the premises.

MANAGEMENT

To prevent vole damage, you need to manage the population in an area before it reaches high numbers. This can often be achieved by removing or reducing the vegetative cover, thus making the area unsuitable to voles. Removing cover also makes detecting voles and other rodents easier. It is important to act before vole numbers increase rapidly because the damage these animals do to ornamental and garden plants and trees can be quite severe.

Monitoring Guidelines

Be alert for the presence of voles. Look for fresh trails in the grass, burrows, droppings, and evidence of feeding in the garden and surrounding area. Pay particular attention to adjacent areas that have heavy vegetation because such areas are likely sources of invasions.

Habitat Modification

One way to effectively deter vole populations is to make the habitat less suitable to them. Weeds, heavy mulch, and dense vegetative cover encourage voles by providing food and protection from predators and environmental stresses. If you remove this protection, their numbers will decline.

You can reduce the base area from which voles can invade gardens or landscaped areas by regularly mowing, spraying with herbicides, grazing, or tilling grassy areas along ditch banks, right-of-ways, or field edges adjacent to gardens. If feasible, weed-free strips can also serve as buffers around areas to be protected. The wider the cleared strip, the less apt voles will be to cross and become established in gardens. A minimum width of 15 feet is recommended, but even that can be ineffective when vole numbers are high. A 4-foot-diameter circle around the base of young trees or vines that is free of vegetation, or a buffer strip 4 feet or more along a row of trees, can reduce problems because voles prefer not to feed in the open.

Exclusion

Wire fences at least 12 inches above the ground with a mesh size of ¼ inch or less will help to exclude voles from entire gardens. These fences can either stand alone or be attached to the bottom of an existing fence (Fig. 3). Bury the bottom edge of the fence 6 to 10 inches to prevent voles from tunneling

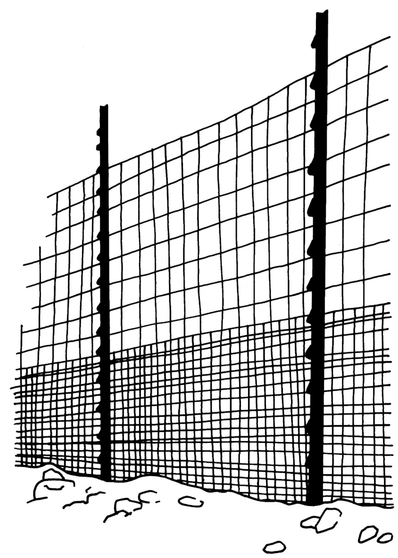

Figure 3. Wire fence.

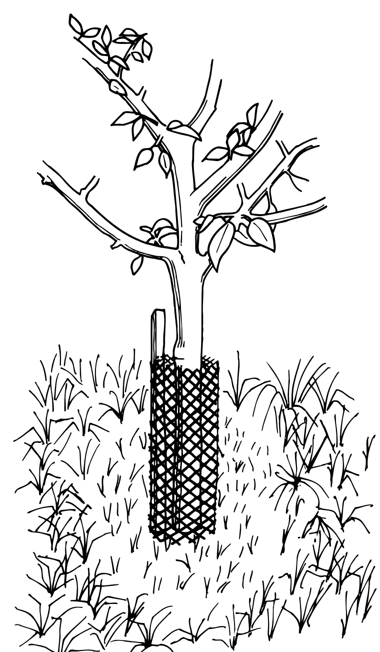

Figure 4. Trunk protection.

beneath it. A weed-free barrier on the outside of the fence will increase its effectiveness.

Young trees, vines, and ornamentals can also be protected from girdling with cylinders made from hardware cloth, sheet metal, or heavy plastic that surround the trunk (Fig. 4). Support or brace these devices so that they cannot be pushed over or pressed against the trunk. Also, make sure they are wide enough to allow for tree growth and, in areas with snow, are tall enough to extend above snow level. Bury the bottom of the protective device below the soil surface to prevent voles from digging under it. Individual milk cartons, tin cans, or plastic soda bottles can also be cut at both ends to fit over small plants. Be sure to *frequently* check protective devices to make sure meadow mice have not gnawed through or dug under cylinders and are hidden by the tree guard while they feed on the tree.

Trapping

When voles are not numerous or when the population is concentrated in a small area, trapping may be effective. Use a sufficient number of traps to control the population: for a small garden a dozen traps is probably the minimum number required, and for larger areas at least 50 or more may be needed. A simple, wooden mouse trap baited with a peanut butter-oatmeal mixture or apple slices is commonly used. Often, no bait is needed because voles will trigger the trap as they pass over it.

Trap placement is crucial. Voles seldom stray from their runways, so set traps along these routes. Look for burrows and runways in grass or mulch in or near the garden. Place baited traps at right angles to the runways with the trigger end in the runway. Examine traps daily and remove dead voles or reset sprung traps as needed. Continue to trap in one location until no further voles are caught, then move the trap to a new location 15 to 20 feet away. Destroy old runways or burrows to deter immigration of new voles to the site.

Bury dead voles or place them in plastic bags in the trash. Because voles may carry infectious pathogens or parasites, do not handle them without rubber gloves; you can use a plastic bag slipped over your hand and arm as a glove. Once the vole is removed from the trap, hold it with your “bagged” hand and turn the bag inside out while slipping it off your arm and hand. Be sure to keep small children and pets out of the area where you have set traps.

Baiting

When voles are numerous or when damage occurs over large areas, toxic baits may be the quickest and most practical means of control. Take necessary measures to ensure the safety of children, pets, and nontarget animals; follow all product label instructions carefully.

Anticoagulants, often referred to as multiple-feeding baits, interfere with an animal’s blood-clotting mechanisms, eventually leading to death. They are probably the safest type of rodent bait for use around homes and gardens because they are slow acting, must be consumed over a period of 5 or more days to be effective, and there is an effective antidote, vitamin K_1. Anticoagulant baits are available at many county agriculture commissioners’ offices as well as at retail stores.

Some anticoagulants such as brodifacoum and bromadiolone cannot be used for voles because of the potential risk they pose to predators such as cats and dogs; check the label carefully to ensure that the bait has voles or meadow mice listed.

Because the pest must feed on anticoagulant baits over a period of 5 days, the bait must be available until the vole population is controlled. Usually baiting every other day for three applications is effective. As with trapping, bait placement is very important. Place the recommended amount of bait in runways or next to burrows so voles will find it during their normal travels. Generally, spot treating (placing bait in a specific place, such as a runway) is the preferred method of baiting, but if there is a heavy ground cover or if the area to be treated is quite large, broadcasting might be a better option if the label allows it. When broadcasting bait, be sure to spread it evenly over the infested area. If you use this technique, you will probably have to broadcast every other day for a total of three or four applications.

Repellents

Commercial repellents are available for protecting plants from voles but their effectiveness is questionable and their use is often not practical. They must be applied before damage occurs. Voles usually damage plants at or just beneath the soil surface, making adequate coverage difficult or impossible. Do not apply repellents to food crops unless such use is specified on the product label.

Natural Control

Many predators, including coyotes, foxes, badgers, weasels, cats, gulls, and especially hawks and owls, eat voles. However, in most cases predators cannot keep vole populations below damaging levels. Many predators simply do not hunt close to homes and gardens where control is needed. Most predators have a broad-based diet and readily shift to alternative prey when the number of voles declines. Predators rarely, if ever, take every last vole; thus, a residual population remains. With their extremely high reproductive potential, any remaining voles could repopulate an area in a short period. With this potential for severe damage, a homeowner or gardener cannot afford to wait for a predator to appear, but must take immediate action to prevent the loss of valuable plantings.

Effective, immediate action usually involves baiting or trapping and habitat modification.

As with all animals, natural constraints limit vole numbers. Because populations will not increase indefinitely, one alternative is to do nothing and let nature limit the voles. Experience has shown, however, that around homes and gardens the natural population peak is too high and damage will be above tolerable limits.

Other Control Methods

Burrow fumigants are not effective for the control of voles because the vole's burrow system is shallow and has numerous open holes. Electromagnetic or ultrasonic devices and flooding are also ineffective against voles.

REFERENCES

Giusti, G. A. 1994. *Protecting Your Garden from Animal Damage*. San Ramon, Calif.: The Solaris Group. 96 pp.

Ingles, L. G. 1965. *Mammals of the Pacific States: California, Oregon, Washington.* Stanford: Stanford Univ. Press. 506 pp.

Johnson, M. L., and S. Johnson. 1982. Voles. In J. A. Chapman and G. A. Feldhamer, eds. *Wild Mammals of North America: Biology, Management, Economics*. Baltimore: Johns Hopkins Univ. Press. pp. 326–354.

O'Brien, J. M. 1994. Voles. In S. E. Hygnstrom, R. M. Timm, and G. E. Larson, eds. *Prevention and Control of Wildlife Damage*, Vol. 1. Lincoln: Univ. Neb. Coop. Ext. pp. B.177–182.

Salmon, T. P. and R. E. Lickliter. 1984. *Wildlife Pest Control around Gardens and Homes.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 21385. 90 pp.

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WEED MANAGEMENT IN LANDSCAPES

Integrated Pest Management for Landscape Professionals and Home Gardeners

Weed management in landscape plantings is often made difficult by the complexity of many plantings: usually more than one species is planted in the landscaped area and there is a mix of annual and perennial ornamentals. The great variety of ornamental species, soil types, slopes, and mulches creates the need for a variety of weed management options. There are also considerations regarding public concern about the use of chemicals to control weeds. The choice of a specific weed management program depends on the weeds present and the types of turf or ornamentals planted in the area. Because of the many variables, weeds in landscape plantings are controlled by a combination of nonchemical and chemical methods.

Most landscape plantings include turfgrass, bedding plants, herbaceous perennials, shrubs, and trees. Information on integrated pest management for turfgrass can be found in *UC IPM Pest Management Guidelines: Turfgrass* (see "References"). Use this publication as a practical review and guide to weed management options suited to general types of landscape plantings.

WEED MANAGEMENT BEFORE PLANTING

An integrated approach, utilizing several options, is the most economical and effective means of controlling weeds. Begin your weed management plan for landscapes before planting by following these five basic steps:

1. *Site assessment.* Before soil preparation and when the weeds are visible, evaluate the soil, mulch, and slope of the site. Identify the weed species in the area, with particular emphasis on perennial weeds. The best time to look for winter annual weeds is mid- to late winter; perennials and summer annuals are easiest to identify in mid- to late summer.

2. *Site preparation.* The most often overlooked aspect of a landscape maintenance program is site preparation. Control existing weeds, especially perennials, before any grading and development are started. Glyphosate (Roundup, etc.) can be used to kill existing annual and perennial weeds. Preplant treatment with fumigants (available to licensed pesticide applicators only) or soil solarization can be used if time allows; however, 6 weeks are required for solarization to work and it is most effective when done during the time of highest sun radiation—from June to August in California.

3. *Define the type of planting.* There are more weed control options if the planting consists entirely of woody plants as opposed to herbaceous annuals or perennial plants, or a mixture of all three.

4. *Don't introduce weeds.* Weeds are sometimes introduced in the soil brought to the landscape site either when amending the soil or in the potting mix of transplants.

5. *Encourage rapid establishment of desired plants.* Use the best management practices to get the plants established as quickly as possible so that they become competitive with weeds and more tolerant of herbicides applied to the site. Handweeding and keeping weeds from producing seeds in the landscape will greatly reduce overall weed populations.

WEED MANAGEMENT AFTER PLANTING

When developing a weed management plan for an existing planting or after an installation is in place, consider the types of plants present and the weeds present and their life cycles (annual, biennial, perennial) (Table 1).

TABLE 1. Common Weeds in Landscape Plantings.

Annuals
- annual bluegrass
- clover (black medic and burclover)
- common groundsel +
- crabgrass (large and smooth) +
- little mallow (cheeseweed)
- pigweed (redroot and prostrate)
- prickly lettuce
- purslane
- sowthistle
- spurge (prostrate and creeping) +
- wild barley
- wild oat

Biennials
- bristly oxtongue +

Perennials
- bermudagrass +
- creeping woodsorrel +
- dandelion
- field bindweed +
- kikuyugrass
- nutsedge (yellow and purple) +
- oxalis (creeping woodsorrel and Bermuda buttercup)

\+ especially troublesome

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Weed control options in the landscape include hand-weeding and cultivation, mowing, mulching, hot water treatments, and chemical control. All of these methods are used at one time or another in landscape maintenance operations (Table 2). After elimination by hand-pulling, cultivation, or a postemergent herbicide application, the subsequent growth of annual weeds can be discouraged with mulches and/or preemergent herbicides.

Cultivation and Hand-weeding

Cultivation (hoeing) and hand-weeding selectively remove weeds from ornamental plantings. These methods are time-consuming, expensive, and must be repeated frequently until the plantings become established. Cultivation can damage ornamentals with shallow roots, bring weed seeds to the soil surface, and propagate perennial weeds. When cultivating, avoid deep tilling, as this brings buried weed seeds to the soil surface where they are more likely to germinate. Perennial weeds are often spread by cultivation and should be controlled or removed by other methods.

Frequent hand-removal of weeds when they are small and have not yet set seed will rapidly reduce the number of annual weeds. If weeds are scattered at a site, hand-weeding may be the preferred management method. Hand-

TABLE 2. How to Manage Weeds in Five Types of Landscape Plantings.

Type of planting and comments	Recommendations
Woody Trees and Shrub Beds. Densely shaded plantings reduce weeds. Preplant weed control is not as critical as in other types of plantings. It is often necessary to combine treatments for complete weed control.	Control perennial weeds before planting (although control may be possible after planting); use geotextile fabrics with a shallow layer of mulch or use a thick layer of mulch without a geotextile base; use a preemergent herbicide, if needed, and supplement with spot applications of postemergent herbicides and/or hand-weeding. Perennial weeds may be controlled by manual removal, spot applications of glyphosate or glufosinate, or, in some instances, dormant-season applications of preemergent herbicides. Escaped weeds may be controlled manually or with spot applications of postemergent herbicides.
Woody Ground Cover Beds. Woody ground covers should exclude most weeds; however, weed encroachment during establishment is likely.	Control perennial weeds before planting, although perennial grasses may be selectively controlled after planting with fluazifop (Fusilade, Ornamec), clethodim (Envoy), or other selective grass herbicides. Annual weeds may be controlled with mulch plus a preemergent herbicide, supplemented with some hand-weeding. Use geotextiles where possible but do not use them where ground covers are expected to root and spread. After planting, it is difficult to make spot applications of nonselective herbicides without injuring desirable plants. Postemergent control of most annual and perennial grasses is possible.
Annual Flower Beds. A closed canopy will help shade out many weeds. Periodic cultivations (at 3- to 4-week intervals and between display rotations) will suppress many weeds.	Control perennial weeds before planting and carefully select flower species for weed management compatibility. Annual weeds may be controlled with mulches, preemergent herbicides, frequent cultivation, and/or hand-weeding. Perennial grasses can be selectively controlled with clethodim or fluazifop, or other grass-selective herbicides, but other perennial weeds cannot be selectively controlled after planting. Geotextiles generally are not useful because of the short-term nature of the planting. Avoid nonselective herbicides after planting.
Herbaceous Perennial Beds. Weed management options in herbaceous perennial beds are similar to those for annual flowers, except (1) it is more important to eradicate perennial weeds as there will be no opportunity to cultivate or renovate the bed for several years; and (2) fewer species are included on herbicide labels.	Control perennial weeds before planting; use geotextiles where possible; use mulches with a preemergent herbicide; and supplement with hand-weeding.
Mixed Plantings of Woody and Herbaceous Plants. Weed management is complex because of the diversity of species. Different areas of the bed could receive different treatments. Site preparation is critical because postplant herbicide choices are few.	Plant the woody species first; control perennial weeds in the first two growing seasons, then introduce the herbaceous species. Plant close together to shade the entire area. Another option may be to define use-areas within the bed that will receive similar weed management programs.

weeding can be time consuming and costly but should be included in all weed management programs to keep weeds from seeding.

Young weeds in open areas also can be controlled with small flaming units. Propane burners are available to rapidly pass over young weeds to kill them. A quick pass over the plant is all that is necessary; do not burn the weed to the ground. Flaming is more effective on broadleaf weeds than grasses. Be careful not to flame over dry vegetation and dry wood chips or near buildings and other flammable materials, and don't get the flame near desired plants.

The top growth of older weeds can be controlled by using a string trimmer. Annual broadleaf weeds are more effectively controlled than annual grasses because the growing points of grasses are usually below ground. Perennial weeds regrow rapidly after using a string trimmer. Be careful not to girdle and kill desirable shrubs and trees with repeated use of a string trimmer.

Mowing

Mowing can be used to prevent the formation and spread of weed seeds from many broadleaf weeds into cultivated areas by cutting off flower heads. However, weeds that flower lower than the mowing blade are not controlled. Repeated mowing tends to favor the establishment of grasses and low-growing perennial weeds. Mowing of some ground covers can rejuvenate them and make them more competitive against weeds.

Mulches

A mulch is any material placed on the soil to cover and protect it. Mulches suppress annual weeds by limiting light required for weed establishment. Many types of landscape mulches are available. The most common are bark and other wood products and black plastic or cloth materials. Other products that are used include paper, yard compost, hulls from nuts (pecans) or cereals (rice), municipal composts, and stones.

Organic mulches include wood chips, sawdust, yard waste (leaves, clippings, and wood products), and hardwood or softwood bark chips or nuggets. Bark chips are moderate-sized particles (⅕ to ½ inch) and have moderate to good stability, while bark nuggets are larger in size (½ to 2½ inches) and have excellent stability over time. These materials can be used in landscape beds containing herbaceous or woody ornamentals.

The thickness or depth of a mulch necessary to adequately suppress weed growth depends on the mulch type and the weed pressure. The larger the particle size of the mulch, the greater the depth required to exclude all light from the soil surface. Coarse-textured mulches can be applied up to 4 inches deep and provide long-term weed control. Fine-textured mulches pack more tightly and should only be applied to a depth of about 2 inches. If the mulch is too decomposed, it may serve better as a weed propagation medium rather than a means of prevention. Plan to periodically replenish landscape mulches, regardless of particle size, because of decomposition, movement, or settling. If seedlings germinate in mulches, a light raking, hoeing, or hand-weeding will remove the young weeds.

Inorganic mulches, which include both natural and synthetic products, are generally more expensive and less widely used in the landscape. Natural inorganic mulches are stable over time and include materials such as sand, gravel, or pebbles. Most of these products are used in public and commercial plantings. If using a rock mulch, consider placing a landscape fabric underneath it. The fabric creates a layer between the mulch and soil, preventing rock pieces from sinking into the soil. The fabric prevents soil from moving above the rock layer, which would bring weed seed to the surface.

Black plastic (solid polyethylene) can be used underneath mulches to improve weed control. It provides excellent control of annual weeds and suppresses perennial weeds, but lacks porosity and restricts air and water movement. For this reason, black plastic may not be the preferred long-term weed control method in landscape beds.

Synthetic mulches, which are manufactured materials that are called geotextile or landscape fabrics, have been developed to replace black plastic in the landscape. Geotextiles are porous and allow water and air to pass through them, overcoming the major disadvantage of black plastic. Although these materials are relatively expensive and time-consuming to install, they become cost-effective if the planting is to remain in place for 4 or more years. Geotextiles are used mainly for long-term weed control in woody ornamental trees and shrubs. Geotextiles should not be used where the area is to be replanted periodically, such as in annual flower beds or in areas where the fabric would inhibit the rooting and spread of ground covers. Tree and shrub roots can penetrate the materials and if the material is removed, damage can occur to the plant's root system. This might be a concern if a fabric has been in place longer than 5 years. At least one geotextile fabric (BioBarrier) has an herbicide encapsulated in nodules on the fabric that reduces root penetration problems.

Placing a landscape fabric under mulch results in greater weed control than mulch used alone. There are differences in the weed-controlling ability among the geotextiles: fabrics that are thin, lightweight, or have an open mesh allow for greater weed penetration than more closely woven or nonwoven fabrics.

To install a landscape fabric, you can plant first and then install the fabric afterwards using U-shaped nails to peg it down. After laying the cloth close to the ground, cut an "X" over the plant and pull it through the cloth. If laying down a fabric before planting, cut an "X" through the fabric and dig a planting hole. Avoid leaving soil from the planting hole on top of the fabric because this could put weed seeds above the material. Fold the "X" back down to keep the geotextile sheet as continuous as possible. Weeds will grow through any gap in the landscape fabric, so it is important to overlap pieces of fabric and tack them down tightly. Apply a shallow mulch layer (about 1 inch deep) to thoroughly cover the fabric and prevent photodegradation. If weeds grow into or through the geotextile, remove them when they are small to prevent them from creating holes in the fabric. Maintain a weed-free mulch layer on top of the fabric by hand-weeding or by applying herbicides. Use of a rock mulch above a landscape fabric can have greater weed control than fabric plus organic mulch combinations.

Yellow nutsedge grows through all geotextiles but some fabrics are better at suppressing yellow nutsedge than others (for more information, see *Pest Notes: Nutsedge*, listed in "References").

Problems with Organic and Natural Inorganic Mulches. There are several problems associated with the use of organic and inorganic mulches. Perennial weeds such as field bindweed and nutsedges often have sufficient root reserves to enable them to penetrate even thick layers of mulches. Some annual weeds will grow through mulches, while others may germinate on top of them as they decompose. Weeds that are a particular problem are those that have windborne seeds such as common groundsel, prickly lettuce, and common sowthistle. Applying mulches at depths of greater than 4 inches may injure plants by keeping the soil too wet and limiting oxygen to the plant's roots. Disease incidence, such as root or stem rot, may increase when deep mulches are maintained.

When mulches are too fine, applied too thickly, or begin to decompose, they stay wet between rains and allow weeds to germinate and grow directly in the mulch. For best weed control, use a coarse-textured mulch with a low water-holding capacity. When used alone, mulches rarely provide 100% weed control. To improve the level of weed control, apply preemergent herbicides at the same time as the mulch (see Table 3). Supplemental hand-weeding or spot spraying may also be needed.

Avoid mulches with a pH less than 4 or that have an "off odor" such as ammonia, vinegar, or rotten egg smell. These mulches were stored incorrectly and contain chemical compounds that may injure plants, especially herbaceous plants.

If using a composted mulch, temperatures achieved during the composting process should have killed most weed seeds. However, if the compost was stored uncovered in the open, weed seeds may have been blown onto the mulch. Be sure the mulch is not contaminated with weed seeds or other propagules such as nutsedge tubers.

Hot Water or Steam Treatments

There are several machines currently available that use hot water or steam to kill weeds. These machines are most effective on very young annual weeds or perennials that have recently emerged from seeds. The effect is similar to that of a nonselective, post-emergent herbicide. Hot water and steam are not very effective on perennial weeds with established storage organs, such as rhizomes and bulbs, nor do they control woody plants. In general, broadleaf weeds are more easily controlled by this method than grasses. The equipment is expensive to purchase and maintain, so these machines are not appropriate for home use. However, commercial landscapers may find them useful in certain situations where the use of herbicides is not desired such as when line-marking playing fields, in playgrounds, around woody plants, for edging, and for weeds growing along fence lines. Some brands of equipment travel slowly (about 2 mile/hour) and are probably not cost-effective for weed control along roadsides. Because these methods employ boiling water or steam, workers must be adequately trained in the use of the machines to prevent severe burns.

Herbicides for Landscape Plantings

Herbicides have been effectively used in many types of landscape plantings and are most often integrated with the cultural practices discussed above. Generally, home gardeners should not need to apply herbicides to existing landscape plantings. Hand-weeding and mulching should provide sufficient control and avoid hazards to desirable plants associated with herbicide use. Many herbicides listed here are for use by professional landscape pest managers and are not available to home gardeners. To determine which herbicide(s) are in a product, look at the active ingredients on the label.

Preemergent Herbicides. When weeds have been removed from an area, preemergent herbicides can then be applied to prevent the germination or survival of weed seedlings. Preemergent herbicides must be applied before the weed seedlings emerge. Examples of preemergent herbicides include: DCPA (Dacthal), dithiopyr (Dimension), isoxaben (Gallery), metolachlor (Pennant), napropamide (Devrinol), oryzalin (Surflan, Weed Stopper), oxadiazon (Ronstar), oxyfluorfen (Goal), pendimethalin (Pendulum, Pre-M), and prodiamine (Barricade). DCPA, dithiopyr, oryzalin, napropamide, pendimethalin, and prodiamine control annual grasses and many broadleaf weeds and can be used safely around many woody and herbaceous ornamentals. Metolachlor has become popular because it controls yellow nutsedge as well as most annual grasses. Isoxaben is used for control of broadleaf weeds.

Timing of a preemergent herbicide application is determined by when the target weed germinates, or by when the weed is in the stage that is most sensitive to the herbicide. In general, late summer/early fall applications of preemergent herbicides are used to control winter annuals, while late winter/early spring applications are used to control summer annuals and seedlings of perennial weeds. If heavy rainfall occurs after preemergent herbicide application or if a short residual product was applied, a second preemergent herbicide application may be needed. Generally, herbicides degrade faster under wet, warm conditions than under dry, cool conditions.

No cultivation should occur after an application of oxyfluorfen; however, shallow cultivation (1 to 2 inches) will not harm napropamide, pendimethalin, or oryzalin. Also, soil type and pH can affect the activity of some herbicides. Use the information contained in herbicide labels and from your local county Cooperative Extension office to determine the tolerance of an ornamental plant species to a given herbicide.

Match herbicides with weeds present, and consider using herbicide combinations. Combinations of herbicides increase the spectrum of weeds controlled and provide effective control of grasses and many broadleaf weeds. Commonly used combinations include tank mixes of the materials listed above or isoxaben/trifluralin (Snapshot), oryzalin/benefin (XL), oxyfluorfen/oryzalin (Rout), and oxyfluorfen/pendimethalin (Ornamental Herbicide II). Check the label to determine which ornamental species the material can safely be used around and which species of weeds are controlled.

Postemergent Herbicides. When weeds escape preemergent herbicides or geotextile fabrics, postemergent herbicides can be used to control established weeds. Postemergent herbicides control existing plants only and do not give residual weed control. Their primary function is to control young annual species, but they are also used to control perennial species. Clethodim and fluazifop selectively control most annual and perennial grasses. Glufosinate (Finale), diquat (Reward), and pelargonic acid (Scythe) are nonselective, contact herbicides that kill or injure any vegetation they contact. They kill annual weeds, but only “burn off” the tops of perennial weeds. Glyphosate (Roundup Pro and others) is a systemic herbicide. It is translocated to the roots and growing points of mature, rapidly growing plants and kills the entire plant. It is effective on most annual and perennial weeds.

Mulch and Herbicide Placement. The placement of an herbicide in relation to an organic mulch can affect the herbicide’s performance. Additionally, the characteristics of organic mulches can affect how herbicides work. A mulch that primarily consists of fine particles can reduce the availability of some herbicides. The finer the organic material (compost or manure, compared to bark), the greater the binding of the herbicide. Most herbicides are tightly bound by organic matter, and while the binding minimizes leaching, it can also minimize an herbicide’s activity. Mulch that is made up of coarse particles will have little effect on herbicide activity.

Another important factor is the depth of the mulch. An herbicide applied on top of a thin mulch may be able to leach through to where the weed seeds are germinating, but when applied to the top of a thick layer of mulch it may not get down to the zone of weed seed germination. Products like oxadiazon (Ronstar) and oxyfluorfen (Goal) that require a continuous surface layer must be placed on the soil surface under the mulch. Suggestions for use of mulch with herbicides are given in Table 3.

Avoiding Herbicide Injury. Because of the close proximity of many different species of plants in the landscape, herbicide injury may occur, resulting in visual plant damage. Herbicide injury symptoms vary according to plant species and the herbicide and can include yellowing (chlorosis), bleaching, root stunting, distorted growth, and the death of leaves. Granular formulations of preemergent herbicides are less likely to cause injury than sprayable formulations. Using a granular formulation reduces the potential for foliar uptake, but granules of oxadiazon (Ronstar) or oxyfluorfen (Goal) mixtures will injure plants if they collect in the base of leaves or adhere to

TABLE 3. Suggestions for Placement of Herbicide with an Organic Mulch.

Herbicide	Application
Devrinol (napropamide)	under the mulch
Gallery (isoxaben)	best under the mulch, moderate control when applied on top of mulch
OHII (pendimethalin plus oxyfluorfen)	works well both under or over mulch
Pennant (metolachlor)	under the mulch
Ronstar (oxadiazon)	over the mulch
Rout (oryzalin plus oxyfluorfen)	works well both under or over mulch
Surflan (oryzalin)	best under the mulch but provides some control when applied on top of mulch
Surflan plus Gallery	under the mulch but will give a fair amount of control even when applied on top of mulch
Treflan (trifluralin)	under the mulch
XL (oryzalin/benefin)	under the mulch

wet leaves. Apply nonselective herbicides such as diquat, pelargonic acid, or glyphosate with low pressure and large droplets on a calm day. Use shielded sprayers when making applications around ornamentals to avoid contact with nontarget plants.

Herbicide injury to established plants from soil-applied chemicals is often temporary but can cause serious growth inhibition to newly planted ornamentals. Herbicides that contain oryzalin or isoxaben are more likely to cause this injury. Injury may result when persistent herbicides are applied to surrounding areas for weed control in turf, agronomic crops, or complete vegetative control under pavement. Activated charcoal incorporated into the soil may adsorb the herbicide and minimize injury. Usually it just takes time for herbicide residues to completely degrade. To speed degradation, supplement the organic content of the soil and keep it moist but not wet during periods of warm weather.

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REFERENCES

Dreistadt, S. H. 1992. *Pests of Landscape Trees and Shrubs*. Oakland: Univ. Calif. Agric Nat. Res. Publ. 3359.

Fischer, B. B., ed. 1998. *Grower's Weed Identification Handbook*. Oakland: Univ. Calif. Agric Nat. Res. Publ. 4030.

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Annual Bluegrass

Integrated Pest Management for Home Gardeners and Landscape Professionals

Figure 1. Annual bluegrass.

Annual bluegrass, *Poa annua*, (Fig. 1) is one of the most common weeds of turf, ornamental plantings, and gardens in the United States. Commonly referred to as "Poa," it is a particular problem in golf course greens and fairways throughout the world. It also can be a weed in vegetable crops and agronomic crops. Though present in tree and vine crops in California, it is usually not a significant problem. The genus *Poa* consists of about 200 species worldwide. Their typical "boat-shaped" leaf tips (Fig. 2), which curve up like the bow of a boat, are a distinguishing characteristic of the genus.

Three members of the genus *Poa* are commonly found in turf. Kentucky bluegrass (*Poa pratensis*) is a common cool-season turf species that is well adapted to cool, well-watered sites such as coastal and intermountain areas. Rough bluegrass (*Poa trivialis*) is a less desirable turf/weed species that does well in moist, shaded areas, but lacks heat and drought tolerance. Annual bluegrass is a weedy species that, unlike Kentucky and rough bluegrass, is able to survive low mowing heights (less than 1 inch) and still reseed. Annual bluegrass is native to Europe but is distributed worldwide.

IDENTIFICATION AND LIFE CYCLE

Annual bluegrass is a misnomer because there are two plant types of annual bluegrass: a true annual (*P. annua* var. *annua*) and a perennial type (*P. annua* var. *reptans*). While the two types are not easy to distinguish from each other, the annual type is more upright in its growth habit and produces more seed than the lower-growing perennial type. The annual type also tends to produce a higher percentage of dormant seed. The perennial type produces seed that germinate readily under optimum conditions. Depending on the site there may be a predominance of one type or a mixture of both. The perennial type is common in such sites as golf course greens, while the annual type may be more common in lawns and parkways (although both types can be found under either of these conditions).

Annual bluegrass starts germinating in late summer or fall as soil temperatures fall below 70°F and continues to germinate throughout winter. This allows several flushes of germination at any one site throughout winter. Annual bluegrass grows to a height of 6 to 8 inches when left unmowed. It has light green, flattened stems that are bent at the base and often rooted at the lower stem joint. Leaf blades are often crinkled part way down and vary from 1 to 3 inches in length with typical Poa, boat-shaped leaf tips. The inflorescence (flowering structure) is a terminal panicle that varies from 1 to 4 inches in length. Seed head initiation can start as soon as plants are 6-weeks old in early fall and continue until early summer, but most seed heads are formed in spring.

Figure 2. Annual bluegrass leaf tip.

The annual form of annual bluegrass is a rapid and prolific seeder. Each small plant can produce about 100 seed in as few as 8 weeks. Viable seed can be produced just a few days after pollination, which allows the plant to reseed even in frequently mowed turf. The seed is amber colored and about 1/16 inch long.

Annual bluegrass has a fairly weak, shallow, root system and needs available moisture from rainfall or frequent irrigation to survive. It grows well in moist areas in full sun. However, it can also do well in semi-shaded conditions. Annual bluegrass can also grow in compacted soil conditions. In coastal regions or in moderate temperature areas where turf is frequently irrigated, annual bluegrass may persist all year. In warmer areas, it usually dies in summer.

IMPACT

Annual bluegrass can be a major weed problem for turf and landscape managers. In turf it forms a weak sod that provides poor footing for athletic fields and golf courses. In addition,

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unsightly seed heads of annual bluegrass reduce the aesthetic quality of the turf. Because of its winter growth habit, it is more competitive than warm-season turf cultivars (common bermudagrass, zoysiagrass, and hybrid bermudagrass) during the cool season. This accounts for the severity of annual bluegrass invasions during winter. Although annual bluegrass can be a problem in all turf species, it is most obvious in bermudagrass and bentgrass. In the cool season, annual bluegrass grows faster than warm-season turf cultivars, which gives infested turf an undulating or irregular surface in as little as 2 days after mowing.

When annual bluegrass infests ornamental plantings, it forms a dense mat that can reduce the vigor of desirable landscape plants by reducing available nutrients in the soil surface. Because of the dense seedling infestations that can occur, hand-pulling or hoeing to remove annual bluegrass is often futile as new flushes of seedling plants germinate after the older seedlings are removed. Hoeing or hand-weeding must be done frequently to be successful. Thus, controlling it manually is very expensive in commercially maintained landscapes and not always successful. In established woody shrubs and trees, annual bluegrass probably has little detrimental effect but may be aesthetically distracting.

Once a few annual bluegrass plants become established in turf or ornamental areas, spread can be rapid because of its prolific and rapid seed production. Seeds are spread by mowing, foot traffic, birds, and cultivation.

MANAGEMENT

A primary method of control is the prevention of new infestations. Mowers and cultivation equipment should be thoroughly cleaned before moving from infested to weed-free areas. If solitary plants of annual bluegrass are found, they should be removed before seed production starts. Isolate small areas with infestations until control can be accomplished. Maintain turf and ornamental areas properly to assure maximum vigor, which helps these plantings become as competitive as possible and slows invasion of the weed. Dense turf and ornamentals shade the soil surface, making the establishment of annual bluegrass seedlings difficult.

Overwatering, especially in shady areas, will predispose turfgrass to annual bluegrass invasion. Use deep and infrequent irrigation to discourage the development of the shallow-rooted annual bluegrass populations. Withhold water until the desirable species are beginning to show drought stress. Avoid fertilization and don't aerate turf during the peak of annual bluegrass germination. Avoid cultural practices and use patterns that might tend to promote soil compaction.

Turfgrass

No single control procedure has been successful in controlling annual bluegrass in turfgrass. Early removal of solitary infestations has been successful when practiced diligently. Open spots should be overseeded to establish a vigorous turfgrass. Removal of grass clippings may help to reduce the number of seed that reach the soil. Check the irrigation output to be sure shady areas are not getting too much water.

Preemergent herbicides such as benefin, bensulide, DCPA, dithiopyr, oxadiazon, pendimethalin, and prodiamine have been successful in limiting germination of annual bluegrass, but they must be applied before weed seeds germinate to be effective. Pronamide is also available for preemergent use, but it can only be applied to warm-season turf. These herbicides (with the exception of pronamide) will not control emerged plants. To limit bluegrass germination during winter, apply preemergent herbicides in late summer or early fall, when soil temperature drops below 70°F. Where the perennial type is a large component of the bluegrass population, preemer-

TABLE 1. Summary of Herbicides for Annual Bluegrass Control

Site	Material	Applied to soil before weed seed germinates	Applied to actively growing plants	Readily available to home gardeners
Turfgrass	benefin	X	—	yes
	bensulide	X	—	yes
	DCPA	X	—	no
	dithiopyr	X	—	no
	ethofumesate	—	X	no
	fenarimol	—	X	no
	glyphosate	—	X	yes
	oxadiazon	X	—	no
	pendimethalin	X	—	yes
	prodiamine	X	—	no
	pronamide	X	X	no
Ornamentals	benefin/trifluralin	X	—	yes
	benefin/oryzalin	X	—	no
	glufosinate	—	X	no
	glyphosate	—	X	yes
	nananoic (pelargonic) acid	—	X	yes
	oryzalin	X	—	yes
	oxadiazon	X	—	no
	pendimethalin	X	—	yes
	prodiamine	X	—	no

X = yes
— = no

gent herbicides will be of little or no benefit.

Postemergent herbicides can limit growth of annual bluegrass but have been of little benefit when used as the sole method of control. Ethofumesate has been used in perennial ryegrass, Kentucky bluegrass, and dormant bermudagrass to reduce annual bluegrass infestations. Pronamide can be used in warm-season turfgrass for established annual bluegrass, but it is slow acting (15–21 days). Repeated applications of the fungicide fenarimol have been reported to reduce the annual type of annual bluegrass infestations.

Annual bluegrass infestations often become so severe that complete renovation is necessary. This can be done by fumigation followed by replanting with a desirable turf species or by spraying the entire area with a nonselective herbicide such as glyphosate. Planting and establishment of the desired species should take place during late spring and summer so that a solid cover of new turf can be obtained before the annual bluegrass germination period. Choose a species and variety that will compete well with bluegrass. Then preemergent herbicides can be used in late summer or fall to further limit annual bluegrass from establishing.

Ornamentals

Annual bluegrass can be controlled by various methods in ornamentals. Prevention of germination and seeding is very important. Hand-removal or spot spraying of solitary plants will save time and money in the long run. Cultivation or hand-hoeing, although possible under some circumstances, is generally not useful unless continued throughout the germination period.

Mulching with landscape fabrics can be effective if the fabric is overlapped so that no light is allowed to reach the soil. Use a polypropylene or polyester fabric or black polyethylene (plastic tarp) to block all plant growth. Rock or organic mulches can be used over the top of the synthetic fabrics. Organic mulches should be at least 3 inches thick. If seed of annual bluegrass gets into the mulch, it may germinate and establish, just as if it were in soil. In these cases the annual bluegrass plants can be easily removed by hand. Mulch thickness will need to be replenished periodically to maintain cover and eliminate light penetration to the soil.

Preemergent herbicides such as oryzalin, oxadiazon, pendimethalin, prodiamine, or a combination of benefin plus trifluralin or benefin plus oryzalin can be used to limit seedling germination in sites where use of these materials is permitted. Make the application before seed germinates in fall when soil temperatures go below 70°F. Preemergent herbicides will be of little benefit if established annual bluegrass plants or the perennial type of bluegrass are already present. However, if the existing bluegrass is removed, a preemergent herbicide can be applied to control seedlings that germinate later.

Few postemergent herbicides are registered for use in established ornamental plantings. Spot treatment with glufosinate, glyphosate, nananoic acid, or other nonselective herbicides can reduce annual bluegrass populations, but one must be careful not to spray or let these herbicides drift onto desirable plants, or the plants will be injured. Other materials, such as fluazifop and sethoxydim, are available but are not effective for annual bluegrass control.

REFERENCES

Gibeault, V. A. and N. R. Goetze. 1973. Annual meadow-grass. *J. Sports Turf Res. Inst*. 48:48-53.

Lloyd, M. C. and E. R. McDonald. 1992. Effectiveness of bensulide in controlling two annual bluegrass subspecies. *Weed Tech.* 6:97-103.

Mitich, L. W. 1998. Annual bluegrass (*Poa annua* L.). *Weed Tech.* 12:414-416.

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits and/or vegetables ready to be picked.

Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse the containers. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Do not pour down sink or toilet. Consult your county agricultural commissioner for correct ways of disposing of excess pesticides. Never burn pesticide containers.

BERMUDAGRASS

Integrated Pest Management for Home Gardeners and Landscape Professionals

Bermudagrass (*Cynodon dactylon*) is a plant that is grown as a turfgrass or as forage for livestock, but it also can be an invasive weed. It was introduced from Africa (not Bermuda) in 1751 and is widely spread throughout the southwest and southern United States. It is found in most areas of California at elevations below 3,000 feet and is common in gardens, landscapes, turf areas, orchards, roadsides, vineyards, and industrial areas. Bermudagrass also has many other common names including couchgrass, devilgrass, wiregrass, or dogtooth grass.

Improved hybrids of bermudagrass (Tifgreen, Tifdwarf, Tifway, Santa Ana) with fine leaves and a longer season of dark green color have been developed specifically for use as turfgrass. These hybrid varieties do not produce seed, whereas common bermudagrass produces seed that remain viable in soil for at least 2 years.

IDENTIFICATION AND LIFE CYCLE

Bermudagrass is a low-growing, wiry perennial (Fig. 1) that has two types of shoots: those aboveground (stolons) and those below ground (rhizomes). The stolons and rhizomes are capable of rooting in the soil, thus creating new plants as they grow out from the original plant or when they are cut and left on moist soil. In areas where the soil has not been disturbed, rhizomes are shallow (1 to 6 inches). But where the soil has been spaded or tilled deeper than 6 inches, or in sandy soil, under sidewalks, and against solid structures such as building foundations or walls, the rhizomes may be deeper than 6 inches. Leaves are generally smooth and pointed with a conspicuous ring of white hairs at the junction of the blade and sheath. The prostrate stems typically have a papery leaf sheath at each node. The stems root at the nodes in moist soil. Flowering stems are upright and bear a terminal group of three to seven spikelike branches, usually originating in a single whorl on the tips of the stem (Fig. 2a). The flowering stem is similar to that of crabgrass (*Digitaria* spp.), but the spikelike branches on crabgrass usually originate about ⅛ to ¼ inch apart at the end of the stem (Fig. 2b), though sometimes they are closer. Individual spikes on the flowering stems of bermudagrass originate at the same point, are 1 to 2 inches long, and bear two rows of spikelets along one side of a flattened rachis (the central stem of the spike).

Bentgrass (*Agrostis* spp.), which also occurs as a patch or large mat in a lawn, may be confused with bermudagrass. Creeping bentgrass (*A. stolonifera*), the species most common in turf, has very fine leaves, stems, and stolons and is without rhizomes. When mowing is frequent, bentgrass does not produce a seed head. In areas that are infrequently mowed, it has a bushy panicle that is about 1½ to 3 inches long (Fig. 2c).

Figure 1. Bermudagrass.

MANAGEMENT

Bermudagrass is not an easy weed to control, especially when it must be controlled selectively within an already

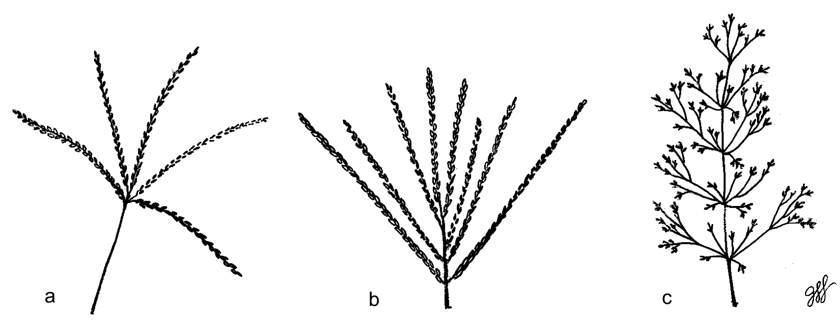

Figure 2. Flowering stems of (a) bermudagrass, (b) crabgrass, and (c) bentgrass.

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planted turf, garden, or landscaped area. It can be managed nonchemically with a persistent program of removal, or over large areas with cultivation and withholding water during the summer to desiccate the stolons and rhizomes. Mulches of black plastic or geotextile landscape fabric can also be effective over large areas if light is excluded. Control with herbicides requires careful timing and often more than one application.

Cultural Control

Although bermudagrass tolerates some drought, it grows best when irrigated. If the area where the bermudagrass is growing can be dried in summer without injuring any nearby ornamentals, withhold water to dry the stems and rototill or spade the area two or three times during summer months. This will bring rhizomes to the surface where they dry out. Raking to remove rhizomes and stolons will also help. If water is applied during the process or it happens to rain, the bermudagrass will regrow. A single, deep (down to 6 inches) cultivation may be adequate, but the time required to dry the remaining rhizomes still buried in the soil will be increased from weeks to months. Be careful not to cultivate bermudagrass if the soil is moist or the weed will spread, because cultivation chops the stems into segments and each segment becomes a new plant. While cultivating and drying can effectively kill established plants and rhizomes, they do not kill seeds in the soil.

Bermudagrass growth can be reduced by increasing shade from trees and tall shrubs. Shaded growth will be fine and spindly; plants are easier to remove than those growing in full sun. Shade from short shrubs or ground covers will not be effective; the bermudagrass will simply grow up through these plants.

Because bermudagrass spreads vegetatively and by seed, it can be spread by clippings from mowing. If lawn clippings are to be used in the landscape, compost them thoroughly to kill seed and vegetative structures and reduce the spread of this weed.

Mulching and Solarization

Mulch can be used in a variety of ways to manage bermudagrass. Black polyethylene applied over bermudagrass to prevent sunlight from reaching the plant can effectively control established plants. Mow and irrigate the grass, place the plastic over the plants, and leave it for at least 6 to 8 weeks in summer. Placing plastic over bermudagrass in winter will not control it. Be sure that the plastic remains intact without holes or bermudagrass will grow through the holes and survive. If ornamentals are planted in holes in the plastic, bermudagrass control is reduced.

Clear plastic mulching (solarization) is effective for eradication of bermudagrass plants and seed if it is applied during periods of high solar radiation. In California's Central Valley, this means during June to August, whereas in coastal areas the best time may be August to September or May to June when fog or wind is most likely to be at a minimum. Before applying the plastic, closely mow the bermudagrass, remove the clippings, and water the area well. It is not necessary to cultivate before solarization, but a shallow cultivation may improve control. Place clear, ultraviolet (UV) protected polyethylene over the area. The plastic should extend roughly 2 feet beyond the bermudagrass stolons to make sure the infested area is covered; it must be maintained intact for 4 to 6 weeks. Shade will reduce the effectiveness of solarization because it limits the amount of radiation. Solarization works most effectively when there is no slope in the land or if there is, the slope has a south or southwest exposure. Temperatures are not as high under plastic placed on a north-facing slope; consequently control is not as effective. After solarization, do not cultivate the area deeper than 3 inches to avoid bringing weed seed into the upper soil layer. (See the soil solarization publication listed in References).

Mulching with products such as wood chips is not effective against bermudagrass because the weed can push up this mulch. If organic landscape (geotextile) fabrics are used under the mulch, however, control can be achieved. The fabric must be overlapped so the stolons do not grow between the fabric sheets. If holes or gaps are present in the fabric, control will be reduced because bermudagrass is likely to grow through the holes. Examples of landscape fabrics include DeWitt's Pro 5, Weed Block, and Typar Landscape Fabric.

Chemical Control of Established Plants

Established stands of bermudagrass can be controlled in the landscape with postemergent herbicides. Postemergent herbicides are applied to bermudagrass leaves and stems when they are growing vigorously (from spring to late summer). The best time and way to apply the herbicide depends on whether it is selective or nonselective. Selective herbicides only kill the specific plants that they are targeted for whereas nonselective herbicides kill most plants they contact. Because nonselective herbicides that control bermudagrass also kill or injure other grasses in the turfgrass, do not apply them to a mixed stand of turfgrass unless you intend to kill other grass species as well.

Selective Herbicides. Early spring is the best time to apply a selective herbicide. For best control with these herbicides, make an application in spring when new bermudagrass growth is less than 6 inches in length, then reapply the herbicide before the regrowth reaches 6 inches in length. Additional applications may be needed as new growth occurs. There may be limits to how much herbicide can be applied in a year so it is important to follow the label. Control is increased if the plant is growing well with plenty of leaf area. Plants that are drought stressed, insect damaged, or with dust on the leaves will not be controlled.

Treating Around Ornamentals. Three herbicides that are safe to use near many ornamental plants (see labels for exact species) are sethoxydim (Grass Getter) and fluazifop (Grass-B-Gon, Ornamec), which are available for use by both the home gardener and licensed pesticide applicator, and clethodim (Envoy), which is available for use by licensed pesticide applicators only.

Treating Turfgrass. In cool-season turfgrasses (annual and perennial ryegrasses, bentgrasses, fine and tall fescues, and Kentucky bluegrass), triclopyr (Weed-B-Gon, Turflon) can be used to suppress bermudagrass. For fescue turfgrasses only, fluazifop (Fusilade) is available to control bermudagrass. Be sure to follow label directions carefully to avoid injury to the turfgrass.

Nonselective Herbicides. Nonselective herbicides are generally applied in late spring or during summer when bermudagrass is growing rapidly. Nonselective herbicides will injure most plants that they contact, so care must be taken that they are not sprayed on desirable plants. Two nonselective herbicides, pelargonic acid (Quik Weed Killer, Scythe) and glufosinate (Finale), are contact herbicides, which means they kill only green parts of the plant that they contact. When the bermudagrass begins to regrow from the underground rhizomes, repeat applications will be necessary. (Both materials are available to use around ornamentals in the home landscape.) In addition, there is a product (Grass and Weed Killer), which combines a selective grass herbicide (fluazifop) with a nonselective contact herbicide (diquat), that is sold for use around ornamentals.

Glyphosate (Roundup and other formulations) is a nonselective herbicide that is translocated throughout the plant so it kills both the tops of the plant and the roots. For it to be most effective, it must be applied to vigorously growing bermudagrass that is not water stressed. Do not mow the bermudagrass for 2 to 3 weeks before applying it and withhold water for 2 to 3 days after an application. For even more effective control, spray the area with glyphosate, leave it for up to 7 days, then cultivate the area to cut surface stolons and bring rhizomes to the surface to dry out. If it isn’t cultivated, another application of glyphosate may be necessary when the weed begins to grow again.

Controlling Bermudagrass Seed

Following the treatment of a stand of established bermudagrass, bermudagrass seed that is present in the soil can still be a problem. Bermudagrass seed will not be controlled with any of the previously mentioned treatments except solarization.

Treating Around Ornamentals. If bermudagrass seeds germinate in areas around ornamental plantings, the seedlings can be controlled with shallow cultivation, hoeing, or a thin layer of mulch.

Treating Turfgrass. Bermudagrass seedlings may emerge in turfgrass that has been treated with postemergent herbicides because postemergent herbicides do not control the seed. On recently planted or established cool-season turfgrass, herbicides can be used to selectively control germinating bermudagrass seed without injuring the turfgrass. Apply a product containing siduron at the time of planting the turfgrass; DCPA (available to licensed pesticide applicators only), trifluralin (Treflan), pendimethalin (Halts, Pendulum), or oryzalin (Surflan) can be used when the turfgrass is greening. Dithiopyr (Dimension) and prodiamine (Barricade, which is available to licensed pesticide applicators only) can be used in established turf. To effectively control new seedlings, apply these herbicides before the seed germinate. Because bermudagrass seed is viable in the soil for 2 years, apply the herbicide each year for 2 years.

Do not use preemergent herbicides, except those containing siduron, just before seeding or sodding a new lawn because they also affect germination of the desired grass species.

REFERENCES

Elmore, C. L., J. J. Stapleton, C. E. Bell, and J. E. DeVay. 1997. *Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 21377.

UC IPM Pest Management Guidelines: Turfgrass. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 3365-T. Also available online at http://www.ipm.ucdavis.edu/PMG/selectnewpest.turfgrass.html

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To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

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Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

CLOVERS

Integrated Pest Management for Landscape Professionals and Home Gardeners

Clover is a broad term that refers to plants in three genera: *Trifolium, Medicago,* and *Melilotus*. Each of these plant genera contains clover species that are troublesome in turfgrass and ornamental areas.

Clover plants have a symbiotic relationship with a bacterium in the *Rhizobium* genus that allows them to fix atmospheric nitrogen and store it in root nodules, which is why clover can maintain a dark green color even under low nitrogen fertility. Turfgrass growing in soil that is low in nitrogen may receive supplemental nitrogen from clover plants as old clover roots die and decay or if the root system is injured.

PROBLEM

Clover can be a concern in turfgrass or landscaped areas for at least three reasons. First, during the flowering period bees are attracted to the clover blooms and people playing or using the turfgrass may be stung. Second, clovers reduce the uniformity of the turfgrass because its texture, color, and growth rate are different from that of grasses. And third, burclover has soft, spiny fruit that are objectionable when the burs mature; the burs are also a problem when they become attached to the fur of pets.

IDENTIFICATION AND BIOLOGY

Depending on the species, clovers may have an annual or perennial life cycle. Both annual and perennial clovers begin to germinate in fall when soil temperatures are in the 50° to 60°F range. Germination continues throughout the winter and early spring months. Winter rainfall will sustain the annual clovers, but irrigation is required for survival of the perennial species during the dry summer months. A weed commonly confused with clovers is *Oxalis*. *Oxalis* has small yellow flowers and does not have the ability to fix nitrogen. For more information on *Oxalis* species, see *Pest Notes: Creeping Woodsorrel and Bermuda Buttercup* listed in "References."

Annual Clovers. Annual clovers that typically cause problems in turfgrass include black medic (*Medicago lupulina*) and California burclover (*Medicago polymorpha*). Another of the annual clovers, little hop clover or shamrock clover (*Trifolium dubium*), is sometimes planted as part of a turfgrass mixture.

Annual clovers grow mostly in a prostrate manner, even without mowing (Fig. 1). Burclover and black medic have trailing stems that branch from the base and radiate out from a single taproot. The compound leaves have three oval-shaped leaflets that are finely toothed with prominent veins (Fig. 2). The central leaflet has a short stem whereas the other two are almost stemless. Flowers are small, bright yellow, and borne in clusters at the end of a stem. In black medic, a single seed is produced in a smooth, small brown to black pod. The burclover seedpod is light brown and either spiny or smooth, but it is curved and contains several seed.

Sweetclovers. Sweetclovers, including white sweetclover (*Melilotus alba*) and yellow sweetclover (*Melilotus officinalis*), are typically more of a problem in ornamental areas than in turfgrass.

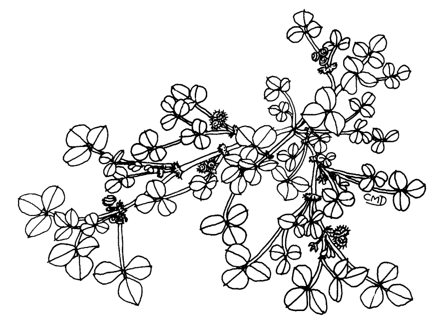

Figure 1. California burclover.

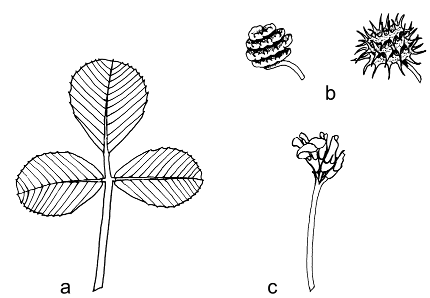

Figure 2. Leaf (a), seedpods (b), and flowers (c) of California burclover.

Sweetclovers are winter annuals or biennials that normally grow from 2 to 5 feet tall (Fig. 3). They have a trifoliate leaf with the leaf margins toothed more than halfway back from the tip (Fig. 4). The flowers are small, yellow or white (depending on the species) and are produced in a many-flowered terminal and in leaf axils. The small pods have one seed.

Perennial Clovers. The perennial white clover, *Trifolium repens*, is most often found as a turfgrass weed, but it and strawberry clover, *Trifolium fragiferum*, are sometimes planted in a mixed stand with turfgrass to reduce the need for nitrogen fertilizer application.

White and strawberry clovers have a creeping stem system (Fig. 5) that roots at the nodes (joints in the stem), forming large clumps. White clover leaves are trifoliate with ¼- to ½-inch-long leaflets (Fig. 6). The flowers of white clover are formed in heads that are white to pale pinkish. Strawberry clover is a more robust plant than white clover and thus more aggressive. The leaves are mostly basal with the leaflets longer and narrower than white clover. The pink flowers are borne in heads that are less showy than white clover.

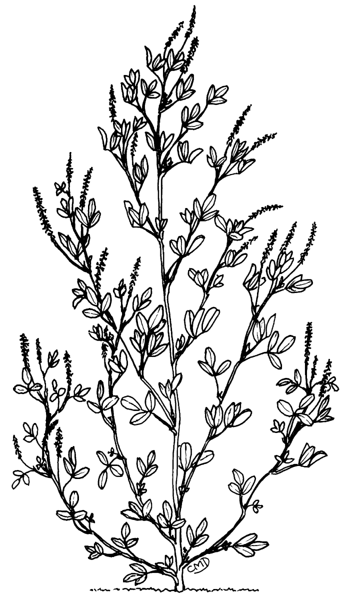

Figure 3. Yellow sweetclover.

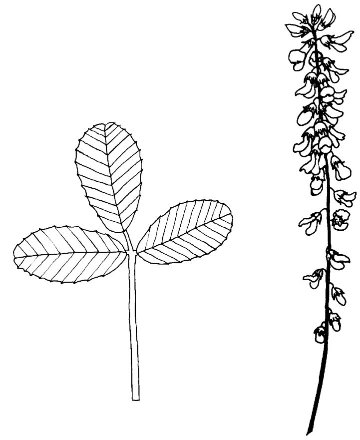

Figure 4. Leaf and flowers of yellow sweetclover.

MANAGEMENT

Clovers are relatively easy to control in the home garden by hand-pulling, cultivation, and the application of mulch. In large, landscaped areas herbicides may also be necessary. Because clover seed has a hard seed coat that is very heat tolerant, composting and solarization are not as effective in reducing clover's seed viability as they are with other weed species. (However, seeds of black medic and burclover are more sensitive to heat than seeds of sweetclovers.) The hard seed coat also allows the seeds to survive longer in the soil than many other weed seeds; clover seeds can germinate over many years, making the control of these plants an ongoing effort.

Once clovers are controlled, change cultural practices in the landscape and turfgrass to reduce the chance of reinfestation. For instance, adjust the fertilizer program to include more nitrogen and less phosphorus in turfgrass or use mulch in landscapes.

Landscaped Areas. Annual clovers can be easily controlled by hand-pulling, hoeing, or cultivation. Mulching, depending upon the size and depth of the mulch, can prevent seedling establishment. Before seeds germinate, apply the mulch 2 to 4 inches deep, depending on the size of the particles (smaller particles, less depth). Mulch can also be applied after the seedlings have germinated but must be applied more thickly (4–6 inches) and must cover the plants completely to block out all light. Larger plants are more difficult to control with mulching, but they can be hand-pulled or hoed.

Preemergent herbicides available for landscape use are effective but generally unnecessary in the home landscape where annual clovers are easily controlled by the methods mentioned. For landscape professionals, herbicide formulations that contain isoxaben are effective for controlling annual clovers and can be used around many woody shrubs and trees. Most established annual flowers tolerate this herbicide. Herbicide formulations containing oryzalin, trifluralin, or pendimethalin will control most grass species and some broadleaf weeds, such as annual clovers, but will miss many other broadleaf species (mustard, aster, legume, and cheeseweed families).

Postemergent control of clover is difficult. If the seedlings are small, glyphosate can be used in open areas provided desirable plants are not sprayed. Once annual clover plants get to 3 to 4 inches in height, control with herbicides is more difficult. The top may be burned, but the plant often regrows. None of the herbicides used

Figure 5. White clover.

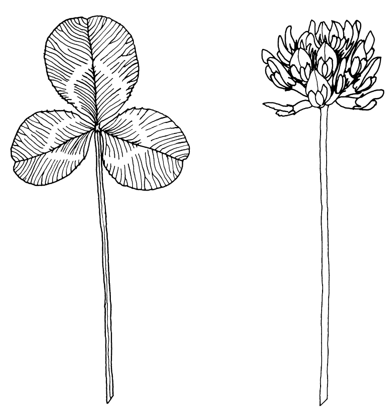

Figure 6. Leaf and flowers of white clover.

in turfgrass for clover control is safe to use in ornamental plantings because they can damage desirable plants.

Perennial clovers can also be controlled with glyphosate when the plants are seedlings, but once the clover is established, it cannot be controlled except by digging it out. Glyphosate at high rates will suppress some clovers.

Turfgrass Areas. Yellow turf and green clover is a good indication of low nitrogen fertility. The invasion of clover into turfgrass can be reduced by using levels of nitrogen fertilizer that will promote grass growth but not the growth of clover; this can be achieved by applying 1 pound of active nitrogen per 1,000 square feet of turfgrass during each month of active turfgrass growth (not to exceed 6 lb active nitrogen/1,000 sq ft/year). Also, high phosphorus in the soil promotes the invasion of clovers. Clover in established turfgrass can not be controlled by fertilization or mowing of the grass. Once clover is established, the annual clovers can be controlled by handpulling before seeds are formed. Handpulling will need to be repeated as new germination occurs and desirable turfgrass planted in weeded areas.

Both established annual and perennial clovers can be controlled with postemergent herbicides. The best herbicide to use depends upon the species of turfgrass. Warm-season turfgrasses such as bermudagrass, zoysiagrass, and kikuyugrass will tolerate products containing mecoprop and dicamba but not triclopyr. Cool-season turfgrasses will tolerate all of the herbicides that control clover. The herbicide 2,4-D is not effective for clover control; it will injure the plant but does control it.

REFERENCES

Elmore, C. L., and D. W. Cudney, Aug. 1997. *Pest Notes: Creeping Woodsorrel and Bermuda Buttercup*. Oakland: Calif. Agric. Nat. Res. Publ. 7444. Also available online at http:/www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7444.html

Elmore, C. L., C. Wilen, D. W. Cudney, and V. Gibeault. July 2000. Weeds from *UC IPM Pest Management Guidelines: Turfgrass*. Oakland: Calif. Agric. Nat. Res. Publ. 3365-T. Also available online at http://www.ipm.ucdavis.edu/PMG/selectnewpest.turfgrass.html

J. C. Hickman, ed. 1993. *The Jepson Manual Higher Plants of California*. Berkeley: Univ. Calif. Press.

Whitson, T. D., ed. 2000. *Weeds of the West*, 9th ed. Jackson, WY: Western Society of Weed Science.

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WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

COMMON KNOTWEED

Integrated Pest Management for Home Gardeners and Landscape Professionals

Common knotweed, *Polygonum arenastrum*, also called wiregrass or doorweed, is common throughout most of the United States and Canada. It is an annual species that is native to Europe and is most often found in compacted soils. This weed is particularly well adapted to the winter and early spring rainfall pattern throughout California. It gets a good start with the early moisture and establishes a taproot, which allows it to survive the summer drought. Other scientific names that have been used for common knotweed in the past are *P. aviculare* and *P. montereyense.*

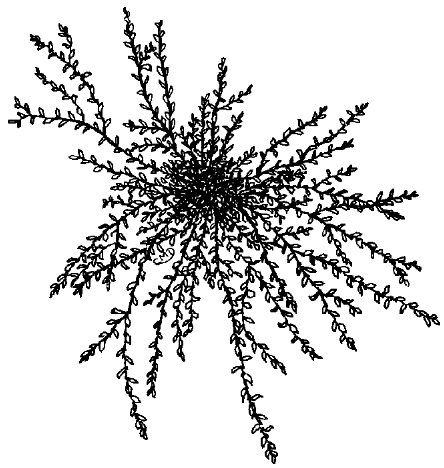

Figure 1. Common knotweed (top view).

IDENTIFICATION

Common knotweed is a prostrate annual plant with numerous slender, wiry stems that are highly branched to form prostrate mats (Fig. 1). However, in cultivated conditions it may ascend slightly to 4 to 8 inches. Seedlings are initially upright with strap-shaped cotyledon leaves (Fig. 2). There is a single taproot that can penetrate to more than 18 inches. Leaves are bluish green in color with blades narrowly ovate in shape (about ½ to 1½ inches in length). The leaf stalk is short and stem nodes are encircled by papery leaf stipules. These stem nodes are slightly swollen giving the typical "knot"-like appearance from which the common name is derived. Flowers are small and inconspicuous; they are borne in the upper leaf axils (Fig. 3). The colors of the flowers range from white to green, and they may have a pinkish tinge. The seed is an achene that is three-sided, dark in color, and about ⅛ inch long.

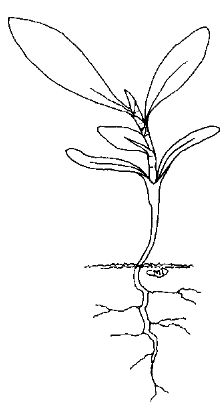

Figure 2. Common knotweed seedling.

Silver-sheathed knotweed, *P. argyrocoleon*, is similar to common knotweed, but has a more erect growth habit ascending to 12 to 20 inches in height. It may be distinguished from common knotweed by its long leafless, rose-colored flower spikes and its shiny seed. Silver-sheathed knotweed is most common in southern California.

In mowed areas, knotweed often resembles spotted spurge (see *Pest Notes: Spotted Spurge* in References). An easy way to distinguish them is to break off a piece of stem. If a white milky sap is exuded, the plant is spurge.

IMPACT

Common knotweed is a frequent weed of turf, roadsides, vacant lots, gravel parking areas, gardens, and any other site that has compacted soil and sufficient moisture to complete its life cycle. It has been found in perennial tree and vine crops as well as in alfalfa, where soil is compacted from frequent traffic. In turf it is found where heavy wear causes soil compaction. It is a typical weed of footpaths or dirt roadways. It can serve as a host for diseases, such as powdery mildew, and is an alternate host for the parasitic weed dodder.

BIOLOGY

Common knotweed germinates in late winter or early spring, when there is sufficient available moisture. It often germinates in soil cracks in compacted soil, and seedlings appear in lines where the cracks are. Though it germi-

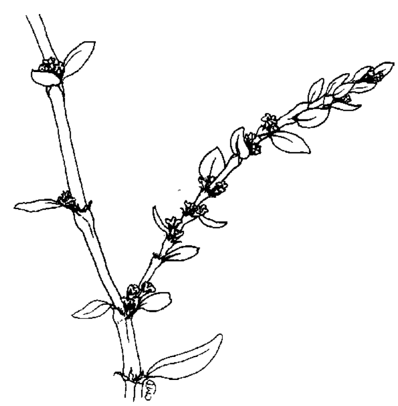

Figure 3. Small, inconspicuous flowers in the leaf axils.

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nates in early spring, it grows slowly and upright before becoming prostrate. If mowed, it remains prostrate and spreads, forming a mat that is 3 to 4 feet in diameter. Seed develop on the plant low to the ground and they readily survive mowing. Flowering may occur from March through October.

MANAGEMENT

One of the best methods of control is to mitigate the condition under which this weed grows best—compacted soils. Arrange landscapes so that there is less likelihood that pathways or other areas will become compacted. Spread out traffic over a broader area. Do not trample areas soon after irrigation or rainfall. Arrange soccer fields and athletic areas so that trafficked areas such as goals, midfields, and sidelines can be rotated.

Aeration or loosening the soil to provide better drainage and a better environment for more desirable species can be beneficial. Prevent knotweed from producing seed by destroying young plants. This will reduce the amount of seed present in the soil in succeeding years. If areas are compacted, loosen the soil and overseed with a locally adapted grass seed.

A variety of mulches can be applied to planting beds and other landscaped areas to prevent establishment of common knotweed. Mulching with landscape fabrics can be effective if the fabric is overlapped and no light is allowed to penetrate to the soil. Use a polypropylene or polyester fabric or black polyethylene (plastic tarp) to block all plant growth. Rock or organic mulches such as bark or compost can be used over the top of synthetic fabrics. If used alone, organic mulches should be at least 3 inches thick. If seed of common knotweed gets into the mulch, it may germinate and establish, just as if it were in soil. In these cases the plants can be easily removed by hand. Mulch will need to be replenished periodically to maintain cover thickness and eliminate light penetration to the soil.

Common knotweed is easy to dislodge with common weeding tools, such as a swivel hoe. For the home gardener, frequent manual removal along with mulching should be sufficient to manage this weed in most situations.

There are many herbicides that will control common knotweed, but they are not generally required in home garden situations. The selection of the herbicide is governed by the site and, should there be one, the crop. Remember that many of these herbicides can have negative effects on desirable plants as well and should be used with care, especially in a landscape situation.

Preemergent herbicides must be applied before the knotweed seed germinates. Examples of preemergent herbicides are atrazine*, benefin, bensulide, dithiopyr, diuron* (for use in turfgrass only), hexazinone*, isoxaben, napropamide*, oryzalin, oxadiazon*, pendimethalin, prodiamine, pronamide*, simazine*, and trifluralin.

Postemergent herbicides like dicamba (for use in turfgrass only), glyphosate, and nonanoic acid will control common knotweed. For best results, these foliar herbicides must be used while the weed is in the juvenile stages, preferably the early seedling stage, before it becomes hardened. When knotweed is young (i.e., less than 3 inches in diameter), it can be controlled with 2,4-D*. Some postemergent herbicides kill the top growth of a plant, but it regrows from the root.

* Available to licensed pest control operators only.

REFERENCES

Cudney, D., C. L. Elmore, and A. Sanders. Aug 1997. *Pest Notes: Spotted Spurge.* Oakland: Univ. Calif. Div. Agric. Nat. Res. Publ. 7445. Also available online at www.ucipm.ucdavis.edu

Hickman, J. C., ed. 1996. *Jepson Manual: Higher Plants of California.* Berkeley: Univ. Calif. Press.

Whitson, T. D., L. C. Burrill, S. A. Dewey, D. W. Cudney, B. E. Nelson, R. D. Lee, and R. Parker. 1996. *Weeds of the West*, 2nd ed. Jackson: Univ. Wyoming.

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COMMON PURSLANE

Integrated Pest Management for Home Gardeners and Professional Horticulturalists

Figure 1. Common purslane.

Common purslane, *Portulaca oleracea* (Fig. 1), is a weedy summer annual species that is abundant throughout the world, invading gardens, low-maintenance lawns, ornamental plantings, commercial orchards, and vegetable crop production areas. It is particularly well adapted to the warm, moist conditions found in California's irrigated agricultural and ornamental sites. Common purslane is also edible with a sweet, yet acidlike flavor. An excellent crunchy salad plant, it is said to blend well with hotter-flavored salad herbs. It has been cultivated in India and the Middle East and has been popular in Europe since the Middle Ages. In the United States, common purslane is a minor crop because of its use in ethnic cooking and its reputed health benefits. Other members of the purslane family include moss rose, miner's lettuce, and redmaids (desert rockpurslane).

IDENTIFICATION AND LIFE CYCLE

Common purslane is a prostrate, succulent annual that often forms a dense mat. The reddish to flesh-colored stems originate from a central rooting point, radiating out like spokes of a wheel (Fig. 2). The stems vary in length, commonly up to 12 inches. Leaves are stalkless (sessile), oval, smooth, succulent, shiny, and vary from 1/2 to 2 inches in length. The leaves, although generally arranged opposite, may also occur alternately along the stem, particularly near the base. Small (3/8 inch), five-petalled, yellow flowers are borne singly in leaf axils and open only in sunshine. Seed are borne in a small pod with a top that comes off like the lid on a cookie jar (Fig. 2). Seed are reddish brown to black, oval, and tiny (about 1/64–1/32 inch in diameter). Common purslane is a prolific seeder. In late summer, flat mats of mature purslane can be turned over to reveal thousands of seed on the soil surface.

Common purslane germinates from February to March in the southern desert areas to late spring in cooler areas when soil temperatures reach about 60°F. It germinates very near to or at the soil surface in large numbers after an irrigation or rain. Most of the tiny seedlings die, but the survivors grow rapidly and can produce flowers in a few weeks. The fleshy stems of common purslane can remain moist and viable for several days after cultivation and hoeing and reroot forming "new" plants when the gardens or fields are irrigated.

IMPACT

Because of its ability to produce large numbers of seed, common purslane can rapidly colonize any warm, moist site. A few scattered plants in the first year can become an almost solid carpet of purslane the following year. Its ability to reroot after cultivation or hoeing frequently enables it to survive these cultural control methods. Common purslane is low in stature and forms dense mats. These vegetative mats utilize available moisture and nutrients and screen out light to the soil surface, preventing emergence of other seedlings. Common purslane is unsightly, reducing the esthetic value of turf and ornamental plantings. In commercial situations common purslane can limit summer vegetable production and reduce the efficiency of harvesting nut crops, such as almonds and walnuts, from the orchard floor.

MANAGEMENT

The primary method of management for common purslane is prevention. Common purslane is such a prolific seeder that once it has become established it is difficult to control. Avoid bringing common purslane into uninfested areas. Use weed-free planting stock and seed. Clean mowers, planters, and cultivation equipment that have been used in infested areas before allowing them to enter clean areas. Monitor uninfested sites for common purslane seedlings and

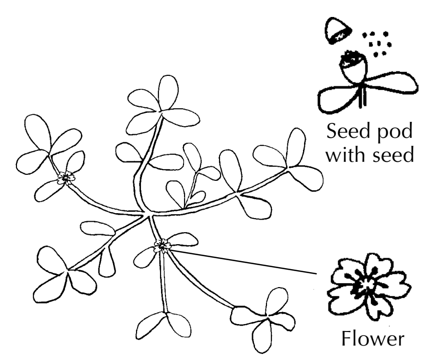

Figure 2. Flower and seed pod.

destroy them before they set new seed. In home landscapes and gardens, this weed is generally managed by cultural means such as hand-weeding and mulching.

Cultural Control

Cultivation following irrigation when common purslane seedlings are small can reduce the weed population. However, because common purslane germinates at or near the soil surface, cultivation can bring up a fresh supply of weed seed from deeper regions of the soil for future germination. Carefully monitor for weed seedlings after each irrigation and cultivate while seedlings are still small. When cultivating or hoeing larger common purslane plants, either remove them or allow plant material to thoroughly dry before irrigation. This will prevent rerooting of the fleshy stem sections. Otherwise, cultivation or hoeing becomes a transplanting operation and little control is achieved.

If they screen out all light, mulches can be used to control common purslane in ornamental plantings, orchards, vineyards, vegetable crops, and gardens. To be effective, organic mulches should be at least 3 inches thick. Synthetic mulches, which screen out light and provide a physical barrier to seedling development, also work well. Combinations of physical barriers with organic or rock mulches on top are commonly used in ornamental plantings.

Soil solarization, the practice of covering moist soil with a clear plastic sheet for 5 to 6 weeks during summer, can kill common purslane and its seed. Solarization is done before gardens and ornamental areas are planted. To work it should be done during summer months when heat and light intensity are highest. Do not disturb the soil or cultivate after solarization as weed seed from deeper layers of the soil may be brought to the surface for germination.

Biological Control

Purslane sawfly is an insect that feeds and reproduces on common purslane. It eats the leaves of common purslane, leaving the plants low in vigor and with little photosynthetic area. Common purslane plants that have been attacked by the purslane sawfly produce fewer seed and are much less competitive with garden and crop plants. Unfortunately, the purslane sawfly attacks common purslane too late in the season. By the time it develops sufficient numbers to have an impact on the common purslane population, seed development and much of the damage from purslane competition in the garden or crop have already occurred.

Chemical Control

Chemical control is generally not necessary for the control of common purslane in the home landscape; it is primarily used in conjunction with cultural methods for commercial situations and should be reserved for use only under unusual circumstances in the home landscape.

There are many preemergent and postemergent herbicides that will control common purslane. If preemergent herbicides are to be used, make sure that they are present at the soil surface during the time of seedling emergence. Tilling the preemergent herbicides deeply (2–3 inches) into the soil has resulted in failure to control common purslane. Postemergent herbicides are effective when applied to the seedling stage; if applied to mature plants, control is often erratic and seed set may have already occurred.

Turfgrass. Common purslane is usually not a problem in healthy, well-established turfgrass. It can be found most commonly in weaker, poorly maintained turfgrass. Therefore, the improvement of cultural practices to obtain healthy, competitive turfgrass is the best method to deal with this weed problem. The herbicides dithiopyr, pendimethalin, prodiamine, or combinations of benefin and trifluralin or benefin and oryzalin (used in bermudagrass turf only) will control common purslane as preemergent treatments. These products are granular materials and some may be mixed with a turf fertilizer. Dicamba and 2,4-D are effective postemergent herbicides in turfgrass and both are available to the home gardener.

Ornamental Plantings. The use of a suitable mulch to limit the light reaching the soil surface can control common purslane in ornamental plantings and may eliminate the need for herbicides. Spot spraying a nonselective postemergent herbicide such as glyphosate or glufosinate can provide good control if care is taken to avoid letting it contact the foliage of desirable plants. Depending on ornamental species and herbicide registrations, several preemergent herbicides will control common purslane. These herbicides include isoxaben, metolachlor, oryzalin, pendimethalin, and trifluralin. Oryzalin and trifluralin are available to the home gardener.

Vegetable Crops. Soil solarization, mulches, and early cultivation of common purslane seedlings can help to control infestations. Preemergent herbicides, if registered for use on the specific vegetable crops, are effective. These herbicides include benefin, bensulide, trifluralin, pendimethalin, and pronamide; of these, only trifluralin is available to the home gardener.

Commercial Orchards. Early, shallow cultivation of common purslane seedlings can help where cultivation is possible. Mulching in the tree or vine row has been successful if the mulch is thick enough (at least 3 inches). Flail mowing done to the soil surface can reduce common purslane seed production. Preemergent herbicides can be effective. In areas with long growing periods (southern California, coastal regions, and the San Joaquin Valley), two preemergent applications may be necessary for season-long common purslane control. Effective preemergent herbicides, depending on crop registration, include bromacil, diuron, EPTC, norflurazon, oryzalin, thiazopyr, trifluralin, and simazine. Careful application of postemergent herbicides such as oxyfluorfen and glyphosate have also been effective; however, repeat applications are usually needed.

REFERENCES

Elmore, C. L., et al. 1997. *Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds.* Oakland: Univ. Calif. Div. Agric. and Nat. Resources, Publ. 21377, 13 pp.

Mitich, L. W. 1997. Common purslane (Portulaca oleracea). *Weed Tech.* 11(2):394-397.

Whitson, T. D., ed. 1991. *Weeds of the West.* Jackson: Univ. Wyoming. 630 pp.

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Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse the containers. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Do not pour down sink or toilet. Consult your county agricultural commissioner for correct ways of disposing of excess pesticides. Never burn pesticide containers.

CRABGRASS

Integrated Pest Management for Home Gardeners and Landscape Professionals

Crabgrass is a common weed that almost everyone knows. (The "great philosopher" Pogo said, "Work is the crabgrass in life.") There are two species of crabgrass common in California: smooth crabgrass, *Digitaria ischaemum* (Fig. 1), and large or hairy crabgrass, *D. sanguinalis* (Fig. 2). Both species were introduced from Eurasia and are widespread throughout the United States. Crabgrass is found in turfgrasses (mostly smooth crabgrass) and in ornamental landscapes (primarily large crabgrass). Large crabgrass is also found in orchards, vineyards, and other agricultural areas. Crabgrass also has many other names including crowfoot grass and summer grass. It is found in most parts of California, except at high elevations and in areas that receive no summer water.

Figure 1. Smooth crabgrass, *Digitaria ischaemum.*

Figure 2. Large crabgrass, *Digitaria sanguinalis.*

IDENTIFICATION AND LIFE CYCLE

Smooth crabgrass is a low-growing, summer annual plant that spreads by seed and from rootings of the culm nodes (joints) that lie on the soil. When unmowed it will grow upright to about 6 inches, but it will tolerate mowing in turf at ¼ inch and will still produce seed at this height. Seedling leaves are light green and smooth. True leaves are dark green and smooth, and the leaf blade is from ¼ to ⅓ inch across, up to 5 inches long, and pointed. Crabgrass often forms patches in lawns, and plants can grow together to form large clumps. The ligule (collar) is small and inconspicuous without prominent appendages or auricles. The leaf sheath and upper leaf surface are smooth, but a few hairs may be found on the lower leaf surface. There may be a reddish tint at the base of the leaf. The inflorescence (flower stalk) has branches that originate from the main stem at ⅛ to ¼ inch intervals. The branches are ½ to 2½ inches long at the end of the stalk.

When found in turf, large crabgrass is a low-growing summer annual that spreads by seed and from rootings of nodes that lie on the soil. When unmowed it may grow upright to a height of 2 feet. It will not tolerate close mowing as well as smooth crabgrass. Seedling leaves are light green and hairy. True leaves are generally 3 inches long and hairy on the upper surface of the leaf and leaf sheath. The collar region and flower stalk are similar to that of smooth crabgrass, but the branches are longer, about 2 to 5 inches, at the end of the stalk.

The flowering stems of crabgrass are similar to those of bermudagrass

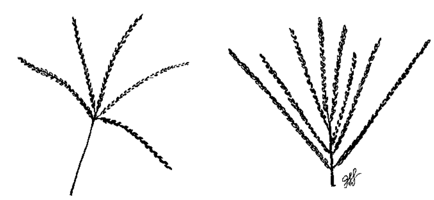

Figure 3. Flowering stems of bermudagrass (*left*) and crabgrass.

(*Cynodon dactylon*), but the spikelike branches on the flowering stems of bermudagrass originate at the same point whereas those on crabgrass originate about ⅛ to ¼ inch apart at the end of the stem (Fig. 3).

In southern California, the major germination period for both crabgrass species is from January 15 to early April, depending on the temperature,

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and seeds continue to germinate throughout spring and summer. While germination is early in warm winter areas, growth is slow during spring months until mid-May. In June and July the plants produce tillers and shoots, and flower in late July and August. In the absence of a frost, crabgrass may overwinter in warm areas or during warm winters and produce new growth and a second crop of seed in spring or early summer.

In the central and northern parts of the state, crabgrass begins germination around March 1 to 15 when soil temperatures reach 50° to 55°F for at least 3 days. Germination continues throughout summer and into fall.

Table 2. Periods of Active Growth of Cool- and Warm-season Turf Species.

Turfgrass species	Period of active growth
Cool-season turf	
annual ryegrass (for overseeding)	October–May
bentgrass	March–June and September–November
fine fescue	March–June and October–December
Kentucky bluegrass	end of February–end of May and October–December
perennial ryegrass	February–June and October–December
tall fescue	March–June and October–December
Warm-season turf	
bermudagrass	April–end of September
dichondra	April–October
kikuyugrass	February–November
St. Augustinegrass	March–October
zoysiagrass	April–October

MANAGEMENT

Crabgrass is easily managed using a variety of cultural and chemical controls.

Cultural Control in Turfgrass

Because crabgrass spreads and reproduces primarily by seed, any cultural operation that reduces seed production will decrease crabgrass. There are also a number of cultural operations that increase the vigor of turfgrass, thus decreasing the potential for a crabgrass invasion. These include using the proper mowing height for turf, applying fertilizer at the correct time of year, selecting the best turf species for your area, overseeding to keep the turfgrass thick, and properly irrigating turf.

Table 1. Proper Mowing Height for Turfgrass Species.

Turf species	Mowing height (inches)
bentgrass, colonial	0.5–1
bentgrass, creeping	0.5 or less
bermudagrass, common	1–1.5
bermudagrass, hybrid	
Santa Ana	0.5–0.75
tifgreen	0.25–0.5
tifway II	0.5–0.75
bluegrass, Kentucky	1.5–2.5
dichondra	0.5–0.75
fescue, fine	1.5–2.5
fescue, tall	2–3
kikuyugrass	1–1.5
ryegrass, annual	1.5–2
ryegrass, perennial	1.5–2.5
St. Augustinegrass	1–2
zoysiagrass	0.5–1

Mowing at the optimum height for turf increases turfgrass vigor and reduces the germination and establishment of crabgrass. Select the proper mowing height from Table 1 for the dominant turfgrass species in your turf. After mowing turf that is infested with crabgrass, thoroughly rinse mower to remove seeds, to avoid transferring them to uninfested sites.

Fertilization can also be used to increase turfgrass vigor and reduce the possibility of a crabgrass invasion. The best time to fertilize is when the turf is actively growing, which depends upon the turf species grown (see Table 2). Because crabgrass is not very competitive, a vigorously growing turf will crowd out crabgrass seedlings.

Selecting a turfgrass that is adapted to your local conditions will also help produce vigorous turf. Cool-season species (bentgrass, bluegrass, perennial ryegrass, and tall fescue) are most competitive in coastal and northern regions of California; some of the newer cultivars of perennial ryegrass, Kentucky bluegrass, and tall fescue, however, are even more competitive and grow better than the older cultivars. For example, tall fescue cultivars used for turf vary in their competitive ability with both smooth and large crabgrass. The older fescue varieties (Fawn and Kentucky 31), which grow in an open, upright manner, tend to become invaded by crabgrass. The slower-growing, dwarf-type tall fescue varieties (especially Bonsai) are also easily invaded. Warm-season species (bermudagrass, St. Augustinegrass, zoysiagrass, and dichondra) are most competitive with weeds in interior valleys and desert regions; kikuyugrass is more competitive in south coastal regions.

Irrigation timing and amount can also affect crabgrass germination and growth. Turf that is overwatered or has frequent (daily) light irrigations becomes weak and vulnerable to invasion by this weed. Irrigating infrequently (once a week) will improve turf vigor. Crabgrass is often found first in open areas where there is no turf, along sidewalks where the soil may be warmer, or around sprinkler heads where turf is mowed closer.

Cultural Control in the Landscape

In the landscape, crabgrass can easily be controlled with mulching, hoeing, hand-pulling when the plants are young and before they seed, or with solarization.

In shrub beds, bedding plants, or around trees, mulching with wood products (wood chips, nuggets), composted yard waste, or synthetic landscape fabrics covered with a mulch will control the germination and establishment of crabgrass by blocking sunlight needed for its germination and growth. The depth of a mulch depends on the size of the particles: coarse mulch may need to be 3 to 6 inches deep to control all weeds, whereas a finer mulch may need to be only 2 to 3 inches deep.

Mulch that has been on the soil for a while can provide an adequate growth medium for weeds to germinate and grow in. If seedlings are germinating in the mulch, move the mulch about with a rake to reduce their establishment. Hand-pull escaped crabgrass plants before they seed. Flaming with a hand-held burner will control crabgrass seedlings, but be careful not to set fire to the mulch if it is composed of wood chips or compost.

Clear plastic mulching (solarization) is effective for eradicating crabgrass plants and seed if it is applied during periods of high solar radiation. In California's Central Valley, this means during June to August, whereas in coastal areas the best time may be August to September or May to June when fog or wind is most likely to be at a minimum. Before applying the plastic, closely mow the crabgrass, remove the clippings, and water the area well. It is not necessary to cultivate before solarization, but a shallow cultivation may improve control. Place clear, ultraviolet (UV)-protected polyethylene over the area for 4 to 6 weeks. Shade will reduce the effectiveness of solarization because it limits the amount of radiation. Solarization works most effectively when there is no slope in the land or if there is, the slope has a south or southwest exposure. Temperatures are not as high under plastic placed on a north-facing slope; consequently, control is not as effective. After solarization, do not cultivate the area deeper than 3 inches to avoid bringing weed seed into the upper soil layer. (See the soil solarization publication listed in Reference.)

Chemical Control

Crabgrass is easy to control in both turfgrass and ornamental beds with herbicides that are applied before it germinates (preemergent herbicides) or after it germinates (postemergent herbicides). Read the label to make sure the product can be used on your turf type and around the ornamentals in your landscape.

Turfgrass. Preemergent herbicides that are available for the home gardener for crabgrass control in warm-season (bermudagrass, zoysiagrass) and cool-season grasses (perennial ryegrass, Kentucky bluegrass, tall fescue, fine fescue) include pendimethalin, bensulide, benefin, and trifluralin. (Professional pesticide applicators may also use dithiopyr, oxadiazon, and prodiamine.) Oryzalin is also available to the home gardener, but it is for use in warm-season turf only. Preemergent herbicides must be applied before the crabgrass germinates (usually from mid-January in southern areas of the state to early March in cooler areas).

Use postemergent herbicides when the crabgrass is small (i.e., in the 1- to 3-leaf stage). If the crabgrass is larger, it takes more herbicide to control it and there is a greater chance of injury to the turfgrass. The postemergent herbicide (MSMA) is effective on young crabgrass. When in the 1- to 3-leaf stage, crabgrass can be controlled with one application. If it is larger, more than one application will be required. If temperatures are over 85°F, reduce the rate of the herbicide or the turf may be injured. If temperatures are higher than 95°F, do not make an herbicide application. Dithiopyr can also be used for postemergent control if the crabgrass is young and has less than five leaves.

Ornamental Beds. In landscape areas, crabgrass can be controlled chemically in the home garden with the selective preemergent herbicides oryzalin, trifluralin, and benefin. (Landscape professionals may also use oxadiazon, pendimethalin, and prodiamine.) These materials can be used before crabgrass germinates or after the crabgrass is removed by hoeing or hand-pulling and before crabgrass germinates again.

Crabgrass can be controlled with a postemergent selective herbicide (sethoxydim plus oil, fluazifop, or clethodim) that can be used over or around most broadleaved ornamentals, or with nonselective herbicides such as glyphosate, pelargonic acid, or glufosinate-ammonium. All of these herbicides except clethodim are available for use by the home gardener. Use nonselective herbicides with care to prevent them from contacting desirable shrubs. Control crabgrass before it sets seed; seeds of crabgrass can remain viable at least 3 years in soil.

REFERENCE

Elmore, C. L., J. J. Stapleton, C. E. Bell, and J. E. DeVay. 1997. *Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 21377.

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DALLISGRASS

Integrated Pest Management for Home Gardeners and Landscape Professionals

Dallisgrass, *Paspalum dilatatum*, is a perennial grass that was introduced into the United States from Uruguay and Argentina. It is now naturalized in much of the southern United States. In California, dallisgrass is found throughout the state except at high elevations. It has been used as a pasture grass in wet areas or irrigated sites but is primarily a weed in turfgrass, wet roadside areas, irrigation ditchbanks, and in some orchards and vineyards.

PROBLEM

Dallisgrass creates an unsightly clump in turfgrass that can be a problem in golf courses, sports playing fields, and home landscapes. The stiff clump it forms is different in texture from the other grasses in a turfgrass mixture and can present a hazard in sports fields, causing people to fall. It has a faster growth rate than most other grasses in a turf. The flowering shoot (culm) often escapes mowing and springs back up above the rest of the turf, causing problems in golf courses and sports fields.

IDENTIFICATION

Dallisgrass is a coarse-textured grass that grows in a clump and slowly increases in diameter as its shallow, short rhizomes (underground stems) grow outward (Fig. 1). The rhizomes have short internodes (the length of stem between the joints) that look like concentric rings on its surface. As the clump matures, the center may die and a different grass or weed may be growing in its center. In areas of large numbers of dallisgrass plants, they grow together forming almost a solid planting with uneven texture and poor turfgrass qualities.

The leaves of dallisgrass are fairly wide (¼ to ½ inch) compared to other turfgrasses. If left unmowed, plant leaves will grow 4 to 10 inches long. The flowering stalk grows 14 to 65 inches tall, has hairs at the base of the leaf (ligule), and frequently has a purplish coloration at the base of the stalk. The flower head consists of 2 to 10 racemes (branches near the top of the flowering stalk) that arise from different points along the flower stalk and are often drooping. Each raceme has two rows of flat, egg-shaped spikelets, which contain the seed, along its entire length (Fig. 2).

For information on other troublesome species of grasses, see *Pest Notes* on Annual Bluegrass, Bermudagrass, and Kikuyugrass listed in "References."

BIOLOGY

Dallisgrass produces abundant amounts of seed, which are its primary means of dispersal. Seed usually germinate in spring and summer when soil temperatures are in the 60° to 65°F range and grow to form new clumps. The optimum air temperature range for growth is 80° to 90°F and when temperatures are in this range, plants grow very rapidly. This weed is often found growing in wet areas such as drain ditches, low places, and in turfgrass that is irrigated. It tolerates both sandy and heavy clay soils and, once established, is drought-resistant and frost-tolerant. Dallisgrass does not go off-color in winter like many warm-season grasses. It responds to nitrogen fertilizer and competes well under high fertility.

Figure 1. Dallisgrass.

Figure 2. Dallisgrass flower head.

MANAGEMENT

A major component of dallisgrass management is to prevent new plants from becoming established. In home landscapes, removing young plants by digging them out before they form rhizomes or set seed is the best strategy for control. Mature plants can also be dug out, but they sometimes grow

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back if rhizomes are left behind. In professionally managed turfgrass areas, prevention is an important component in managing this weed. When dallisgrass is present in abundance or the plants are located over a large area, it may be necessary to supplement cultural practices with herbicides.

Prevention

Dallisgrass is probably introduced into lawn areas with new turfgrass seed or with new sod. The seed can also be introduced on mowers that have been used in contaminated sites and then moved to weed-free sites. Cleaning a mower after mowing a contaminated site should reduce the chance of invasion into new areas. Inspect sod before taking delivery to make sure dallisgrass is not present. Don't use soil from dallisgrass-contaminated areas to repair low or bare spots in the turf. In spring when new seedlings germinate, minimize the amount of aeration performed on the turfgrass to avoid small open areas where dallisgrass plants might become established.

Cultural Control

Because dallisgrass is a perennial plant, persistence is required to kill it with cultural practices. In lawn areas the clumps can be removed by digging. Mowing the turfgrass will not remove dallisgrass, but when turfgrass is mowed at its optimum height, it is better able to resist an invasion of dallisgrass. Also, close mowing decreases shoot vigor and results in lower seed production.

When dallisgrass has been established for some time in the turfgrass, seed will be abundantly present in the soil. In well-established turfgrass, seedlings may not be able to establish, but if there are open areas in the turf, seed will germinate in these areas. If bare areas are present, overseed them with desirable turfgrass species to reestablish the turf.

Dallisgrass is not normally a problem in ornamental areas, but if it does occur, the plants can be dug out and a mulch laid over the area to control the seedlings. Along roadsides and fences or in orchards and vineyards, the plants can be dug out during summer and left in place for the clumps of rhizomes to dry. As long as all the rhizomes are dug up and dried, the plant will not regrow. New seed will germinate and establish unless they are removed when they are seedlings.

Mulching with organic materials is not very effective for the control of mature dallisgrass. However, if the tops of the plants are removed, laying black plastic or landscape fabric over the area will control the remainder of the plant as well as any new seedlings. Summer solarization will most likely control dallisgrass also. For information on solarization, see the publication *Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds* listed in "References."

Chemical Control

Where digging out clumps of dallisgrass in turfgrass is not practical, herbicides may be used. Herbicides to control established plants are referred to as postemergent herbicides. These herbicides are either selective and kill only specific weeds, or they are nonselective and kill any plant they come in contact with. To control germinating seed, preemergent herbicides are used.

Established Plants in Turfgrass. The postemergent herbicides MSMA or CMA can be used to control clumps of dallisgrass growing in turfgrass. These herbicides are relatively selective and must be applied two to three times at 3-week intervals in the summer. The turfgrass and dallisgrass should be in good growing condition before application. Also, it is best if the turf is left unmowed for 2 weeks before the first application to get the maximum amount of leaf area to spray the herbicide onto. Withhold irrigation for 24 hours after application. Don't apply these herbicides during hot weather and check the label for rate adjustments during warm weather to minimize the risk of injuring the turfgrass.

Some turf managers have used the nonselective herbicide glyphosate (Roundup) to control dallisgrass in turf. Glyphosate kills both the dallisgrass and the turfgrass, leaving an area of dead turf. To keep the turf vigorous and growing well enough to outcompete germinating dallisgrass seed, the spot needs to be overseeded. Sometimes the dallisgrass is not killed even though the turf is severely damaged or killed, thus requiring a re-treatment. Other nonselective postemergent herbicides are not as effective as glyphosate.

Seed in Turfgrass. Preemergent herbicides can be used in established turfgrass to control germinating dallisgrass seed. Apply preemergent herbicides in late winter or early spring before dallisgrass seed germinate. Herbicides that control crabgrass such as bensulide, pendimethalin, oryzalin, DCPA, prodiamine, oxadiazon, or dithiopyr are also effective on dallisgrass.

Ornamental and Noncrop Areas. In ornamental or noncrop areas, glyphosate can be used as a nonselective treatment to control established plants. Apply glyphosate when dallisgrass is flowering but before seed have been produced. The preemergent herbicides napropamide, pendimethalin, oryzalin, or combinations of benefin plus oryzalin, or benefin plus trifluralin are effective on preventing dallisgrass seed from germinating. Once seedlings appear, then postemergent herbicides are necessary to control them chemically.

REFERENCES

Cudney, D. W., Elmore, C. L., and V. Gibeault. Sept 1999. *Pest Notes: Annual Bluegrass.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 7464. Also available online at http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7464.html

Cudney, D. W., Elmore, C. L., and V. Gibeault. Feb 1999. *Pest Notes: Kikuyugrass*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 7458. Also available online at http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7458.html

Elmore, C. L., and D. W. Cudney. Feb 1998. *Pest Notes: Bermudagrass*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 7453. Also available online at http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7453.html

Elmore, C. L., and W. B. McHenry. 1989. Weed control in turf areas. In *Turfgrass Pests.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 4053. pp.17–48.

Elmore, C. L., J. J. Stapleton, C. E. Bell, and J. E. DeVay. 1997. *Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 21377

Holms, L. G., D. L. Pluckett, J. V. Pancho, and J. P. Herberger. 1977. *The World's Worst Weeds, Distribution and Biology.* Honolulu: The University Press of Hawaii. p. 609.

Murphy, T. R., D. L. Calvin, R. Dickens, J. W. Everest, D. Hall, and L. B. McCarty. 1987. *Weeds of Southern Turfgrasses.* Athens, GA: Coop. Ext. Serv./Univ. GA College of Ag. and Env. Sci.

Selected Weeds of the United States: 1970. U.S. Dept. of Agric.. Agric. Res. Service, Agriculture Handbook No. 366. U. S. Government Printing Office, Washington D.C.

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DANDELIONS

Integrated Pest Management for Home Gardeners and Professional Horticulturalists

Figure 1. Dandelion.

Dandelion (*Taraxacum officinale*), also known as lion's tooth, puffball, blowball, and monk's head, is a major problem in turf, ornamental plantings, meadows, pastures, and alfalfa. The genus *Taraxacum* consists of about 40 species worldwide, but only two are found in California. *Taraxacum californicum* is found in mountain meadows and *T. officinale* is found as a weed throughout California.

Dandelion was introduced from Europe and has been used as a potherb and medicinal plant since Roman times. It has a high vitamin and mineral content. Mature leaves are often dried and used to make a mild tea. Roots are often used to make stronger tea or dried and used for various medicinal purposes including a mild diuretic. Salads, beer, and wine are also made from the leaves and flowers.

IDENTIFICATION AND LIFE CYCLE

Dandelion (Fig. 1) is a perennial that grows best in moist areas in full sun; however, it can survive some shade and dry conditions once established. Dandelion grows year round in California except in the coldest intermountain areas where it is dormant during the winter. It produces a strong taproot that is capable of penetrating the soil to a depth of 10 to 15 feet, but it is most commonly 6 to 18 inches deep. Buds grow from the uppermost area of the root, producing a crown that can regenerate "new" plants even though the plant is cut off at or below the soil surface. Sections of the root as short as 1 inch in length are also capable of producing new plants. There are no true stems, rather the leaves are clustered in a rosette at the base of the plant. Leaves vary in length from 2 to 14 inches and from 1/2 to 3 inches wide. Margins of the leaves (Fig. 2) are deeply serrated forming the typical "lion's tooth" outline from which the name is derived (dent-de-lion = tooth of the lion).

Flowering stalks are 6 to 24 inches in length and terminate in a compound inflorescence or head that contains 100 to 300 ray flowers and looks like a characteristic puffball. Each ray flower has a strap-shaped yellow petal with five notches at the tip. Dandelion flowers are not normally pollinated but develop asexually. Flowering occurs nearly year round in the temperate climatic regions of California. The seeds (Fig. 3) are achenes and are about 1/8 inch in length with five to eight ribs. At the apex of the achene there is a slender stalk (about two to four times the length of the achene) that terminates in a parachute-like structure (pappus), allowing the seed to be transported via wind currents for miles.

Figure 2. Deeply serrated dandelion leaf margin.

Seed germination occurs at or very near the soil surface. Light increases germination. The seed germinates when soil is moist and soil temperature is at least 50°F; however, germination is more rapid when the soil temperatures are closer to 77°F. Germination occurs throughout the grow-

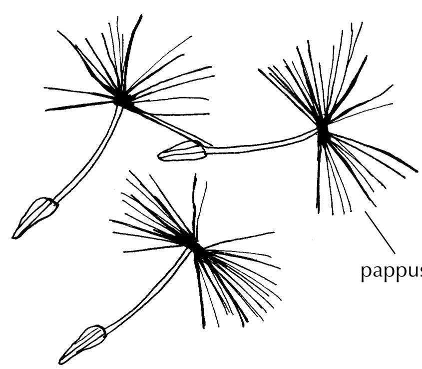

Figure 3. Dandelion seed.

ing season. The seedling stage can last 8 to 15 weeks, depending on temperature and growing conditions. Seedling growth is slower in cold weather.

Flowering begins soon after the seedling stage and continues throughout the life of the plant. Dandelion plants can survive for many years, developing massive, thickened crowns 6 to 10 inches across. These perennial plants are well adapted to irrigated areas such as in turfgrass, pastures, or alfalfa where frequent mowing or grazing is practiced.

IMPACT

Dandelion can be a major weed problem for turf and ornamental managers. In turf, it forms clumps that cause poor footing for athletic fields and golf courses. Dandelion's texture and color vary from that of normal turfgrass and the yellow flowers reduce the aesthetic quality of the turfgrass.

When dandelion infests turfgrass and ornamental plantings, it forms dense circular mats of leaves (6 to 14 inches in diameter) that crowd out desirable species and reduce the vigor of those plants that survive. Because of the extensive root system of established plants, hand-pulling or hoeing to remove dandelion is usually futile unless done repeatedly over a long period of time. Thus, control by this means is most successful in areas such as home lawns and gardens. Once a few plants become established in turfgrass or ornamental areas, their seed can be spread by wind or equipment.

Dandelion is also found in nontilled orchards where mowing is used for weed control. It can be a problem in spring when trees are in bloom because it is very attractive to bees. The pappus on the seed frequently clogs up tractor radiators, and roots of dandelion are attractive to gophers. As a weed in irrigated pastures and alfalfa, dandelion is usually most serious in the intermountain regions of California where these sites remain in production for long periods of time (more than 5 years). Although it is slow to establish, once established it is difficult to control because of its extensive root system.

MANAGEMENT

Because dandelion seed can be windborne for several miles, prevention of new infestations is difficult. Solitary new dandelion plants along fence rows, roadsides, flower beds, and in turfgrass should be grubbed out (digging out the entire plant, taproot and all) before they produce seed. Monitor the area for several months to make sure that removal was complete. Areas with infestations should be isolated and seed heads removed until control can be accomplished. Turfgrass and ornamental areas should be well maintained to assure maximum vigor. Making these plantings as competitive as possible will slow invasion of the weed. Dense stands of turfgrass and ornamentals shade the soil surface, making the establishment of new dandelion seedlings more difficult.

Home Landscapes

In the home landscape, dandelion plants can easily be grubbed out, especially when they are young. Dandelion knives and similar specialized tools are available for removing individual weeds and their roots while minimizing soil disturbance. Control dandelion plants before they set seed to reduce the potential for further invasion by this weed. Also, landscape fabrics (see "Ornamentals" below) can be used to control this weed.

Turfgrass

No single control procedure has been successful in controlling dandelion in turfgrass. Early grubbing of new seedlings has been successful when practiced diligently. These plants must be dug up regularly for several years to be successfully eliminated. Spot spraying isolated plants with glyphosate can be helpful, but the turfgrass is killed, leaving open areas. Overseed the open spots to establish a vigorous turf sod.

The preemergent herbicides commonly used to control crabgrass in turfgrass have not been successful in limiting germination of dandelion. However, a relatively new broadleaf preemergent herbicide, isoxaben, has been effective but, like all preemergent herbicides, must be applied to the soil before the dandelion seed germinates (Table 1).

Postemergent herbicides that control broadleaf weeds (2,4-D, triclopyr,

TABLE 1. Summary of Herbicides for Dandelion Control.

Site	Material	Applied to soil before germination	Applied to young plants	Readily available to home gardeners
Turfgrass	glyphosate	—	x	yes
	isoxaben	x	—	yes
	2,4-D	—	x	yes
	triclopyr	—	x	yes
	MCPA	—	x	yes
	mecoprop	—	x	yes
Ornamentals	isoxaben	x	—	no
	oxyfluorfen	x	—	no
Orchards	glyphosate	—	x	yes

x = yes
— = no

MCPA, and mecoprop) can control dandelion seedlings. Control of established plants with a postemergent treatment is much more difficult; 2,4-D works best for established dandelion control while triclopyr, MCPA, and mecoprop reduce dandelion vigor but do not kill it.

Ornamentals

There are few options for the control of dandelion in ornamental plantings. Prevention is very important. Hand removal or spot treatment of solitary plants with glyphosate will save time and money in the long run. Pulling or hand-hoeing is helpful if done periodically during the year; however, regrowth from the extensive perennial root system limits the effectiveness of this method.

Mulching with landscape fabrics can be particularly effective for controlling seedlings if the fabric is overlapped and no light is allowed to penetrate to the soil. Use a polypropylene or polyester fabric or black polyethylene (plastic tarp) to block all plant growth. Fabric mulches should be covered with an organic mulch to improve aesthetics and to reduce photodegradation. Organic mulches may also be effective in controlling dandelion seedlings if they are at least 3 inches deep and are managed in such a way as to not provide a growth medium for new dandelion seedlings.

Isoxaben and oxyfluorfen have been useful in limiting dandelion when they are applied to the soil before the seed germinates. These materials can only be applied by a licensed pesticide applicator, and control may be difficult because of dandelion's extended germination period. If isoxaben is used, lightly hoe any dandelion seedlings that escape the treatment; if oxyfluorfen is used, do not disturb the soil after application.

Few postemergent herbicides are registered for use in established ornamental plantings. Spot treatment with glyphosate can control existing dandelion plants, but do not allow the spray or drift to contact desirable plants or injury will result.

Orchards

Dandelion can be managed in commercial orchards through summer cultivations or by maintaining a competitive cover crop. Glyphosate is often used to spot treat individual plants.

REFERENCES

Letchamo, W., and A. Gosselin. 1996. Light, temperature and duration of storage govern the germination and emergence of *Taraxacum officinale* seed. *J. of Hort. Sci.* 71(3):373-377.

Mitich, L. W. 1989. Common dandelion—the lion's tooth. *Weed Tech.* 3:537-539.

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Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse the containers. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Do not pour down sink or toilet. Consult your county agricultural commissioner for correct ways of disposing of excess pesticides. Never burn pesticide containers.

FIELD BINDWEED

Integrated Pest Management for Home Gardeners and Professional Horticulturalists

Figure 1. Field bindweed.

Field bindweed, *Convolvulus arvensis*, (Fig. 1) is a native of Eurasia and was first documented in California in 1884 when it was collected in San Diego. By the first quarter of the twentieth century, field bindweed was proclaimed the worst weed in California and many of the western states. Seed most likely arrived in the United States as a contaminant in farm and garden seeds. However, because of its flowers and climbing nature, some seed were probably planted as ornamentals, either as a ground cover or hanging basket. Field bindweed has been given many names including perennial morningglory, creeping jenny, bellbine, sheep-bine, and corn-bind.

IDENTIFICATION

The first two leaves (cotyledons) of a field bindweed seedling are nearly square with a shallow notch at the tip (Fig. 2). Plants that arise from rhizomes (underground stems) lack seed leaves. The first true leaves are arrowhead shaped and have petioles (leaf stems) that are flattened and grooved on the upper surface.

Mature field bindweed plants have arrowhead-shaped leaves that can be between 0.5 to 2 inches long, depending on environmental conditions. Mature leaves at the base of the stem are larger than the young leaves at the stem terminal. The flowers are trumpet shaped, white to pink in color, and 1 to 1.5 inches in width. Field bindweed is a prostrate plant unless it climbs on an object for support. It is often found growing on upright plants, such as shrubs (Fig. 3) or grape vines, with its stems and leaves throughout the plant and the flowers exposed to the light. Under warm moist conditions, leaves are larger and vines more robust than under drought conditions. The root system has both deep vertical and shallow horizontal lateral roots (Fig. 4). The vertical roots can reach depths of 20 feet or more. However, 70% of the total mass of the root structure occupies the top 2 feet of soil. Most of these lateral roots are no deeper than 1 foot. Experiments on bindweed have shown that its root and rhizome growth can reach 2.5 to 5 tons per acre.

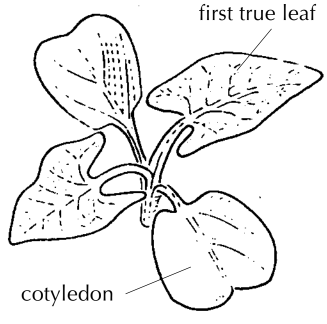

Figure 2. Field bindweed seedling.

Figure 3. Bindweed growing on upright plant.

In contrast to field bindweed, the common annual morningglory of the garden has a larger (2 inches), more showy flower that may be white to blue or purple in color, a thicker stem that is sometimes hairy, and heart-shaped leaves that are 1.5 inches wide and 2 inches or more long. The two species are easy to distinguish from each other.

LIFE CYCLE

Field bindweed is a hardy perennial that is found throughout California below 5,000 feet elevation. It spreads from an extensive rootstock as well as from seed. The root system may reach depths of 20 feet or more and the rhizomes can be several feet long. Most parts of the bindweed roots and rhizomes can produce adventitious

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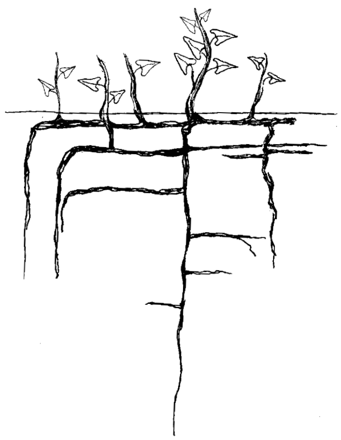

Figure 4. Bindweed root system.

buds, which can create new roots and shoots. Roots capable of budding are found to depths of 14 feet. Fragments of vertical roots and rhizomes that are as short as 2 inches can form new plants. Lateral roots serve another important function. At about 15 to 30 inches from the parent plant, a lateral often turns downward, becoming a secondary vertical root, and sends out both roots and shoots from the turning point. By this means a single field bindweed plant can spread radially more than 10 feet in a growing season. This extensive underground network allows for overwintering without foliage and can persist for many years in the soil.

One to four dark brown seeds are produced in round, smooth, 1/4-inch capsules. An average plant produces about 550 seeds. Within 1 month after forming, the seed coat matures and becomes impervious to water. Seed that is 50 years old has been found to be alive and the seed are commonly found in the soil seedbank. Once the seed coat is weakened, seed will germinate at temperatures of 41° to 104°F.

Drought tolerance is a characteristic of field bindweed. In California, it seems to prefer heavy clay soils rather than sandy soils. When water is withheld, bindweed competes better than most other plants. If the area is well watered, ornamentals may compete better than the bindweed. In the landscape, field bindweed will survive with sprinkler or drip irrigation. If there is no summer water, the plant reduces its seed production first and then reduces growth and leaf size, but some flowers and seed are still produced.

MANAGEMENT

Control of field bindweed is not easy, and it cannot be accomplished with a single treatment or in a single season. Effective control requires prevention of seed production, reduction of stored carbohydrates by deep tillage of the root system, competition for light from other plants, and constant vigilance in removing top growth.

Prevention

There are three practices that can reduce the possibility of introducing field bindweed. Purchase and plant clean seed and ornamental stock; remove any seedlings before they become perennial plants; and prevent any plants from producing seed. If topsoil is introduced to a site, it should be free of propagules and seeds. It is important to control new infestations when they are small, because spot control is least expensive and the most effective.

Cultural Control

Experiments in some annual and perennial crops have demonstrated the effect of shade on bindweed growth. Alfalfa, cereal grains, and corn reduced bindweed growth. Shrubs and trees should also reduce growth, especially if there is another planting under the trees and the bindweed is not allowed to climb above the foliage of these plants.

Seedlings of field bindweed are easy to control with cultivation, but only for about 3 to 4 weeks from germination. After that, perennial buds are formed, and control is much more difficult.

Cultivation or hoeing has been partially effective in reducing established stands of field bindweed. Cultivate about every 2 to 3 weeks, as soon as the bindweed reaches 6 inches in length, and repeat whenever necessary. Withholding water to dry the site may help in conjunction with cultivation to reduce the perennial population in a summer season.

Black polyethylene mulch has been effective for bindweed control *if no light is allowed to reach the soil and the plant*. The edges of the plastic must be overlapped so that the bindweed stems cannot grow between the sheets and into the light. Landscape fabrics have also been effective if all light is excluded. If holes are made in the fabric or plastic for plants, however, bindweed can also grow through these holes. A landscape fabric placed over soil then covered with bark or other organic matter or rock will control field bindweed. It may take more than 3 years of light exclusion before the bindweed is killed. Once the plastic is removed, new bindweed plants may germinate from seed in the soil; be sure to monitor the site and control any new seedlings.

Chemical Control

Herbicides have been relatively effective for suppression of bindweed, but have not been very effective for eradication. If herbicides are used, supplement them with appropriate preventive and cultural controls.

Turfgrass Areas. In turfgrass areas field bindweed is not normally a problem because frequent mowing reduces its vigor, though once established, it will persist. For control, products containing 2,4-D and/or dicamba have been effective without injuring the grass turf. More than one application will have to be made during the summer growing season. Mowing the turfgrass will not get rid of bindweed. Bindweed often will flower above the turf.

Ornamental Areas. In ornamental landscape settings, field bindweed grows between and up through the canopy of plants. For control, products containing trifluralin, oryzalin, or pendimethalin will reduce emerging perennial shoots and control the seedlings, but they will not kill established bindweed plants. In open areas where there are no desirable plants, glyphosate (Roundup and other formulations) should be applied when bindweed plants are flowering but before seed is produced. Glyphosate takes awhile (2 to 3 weeks, depending upon temperature at treatment) to kill the top growth, but it is effective, even though eradication is not always possible. Glyphosate does not have residual activity. It will not affect germination of field bindweed seed, so new seedlings will have to be controlled with mulch, preemergent herbicides, or cultivation.

Some people have used a 2 to 4% solution (volume to volume) of glyphosate to paint the leaves of bindweed in shrub areas, but if you try this be sure not to allow the herbicide to touch mature leaves or green bark of ornamental shrubs or trees or injury may result. To reduce the chance that glyphosate will contact the desirable plants, place the bindweed vines on newspaper before painting the leaves with glyphosate. Once the glyphosate solution has dried on the bindweed leaves, the newspaper can be removed. Any regrowth of the field bindweed must be retreated.

If an area infested with bindweed is to be planted, cultivate the field bindweed to cut it into smaller sections, irrigate the area to make the bindweed grow well, and then treat the field bindweed with glyphosate before planting. After planting, use a preemergent herbicide or mulch and continue to control any seedlings or regrowth from the previously treated plants.

Orchard and Vineyard Areas. In orchards or vineyards where bindweed is growing beneath the branches or canes, glyphosate can be applied safely to the bindweed under the woody crop plants without injuring them. For best control apply glyphosate to the bindweed when it begins to bloom. Glyphosate applications in fall when the bindweed is actively growing are also effective, but spring treatment has the additional benefit of reducing seed production by this weed. Generally, additional applications need to be made when the bindweed regrows. Seedlings must be controlled with mulch, cultivation, or preemergent herbicides before they become established plants. Repeated cultivations are required to prevent bindweed from reestablishing. Because the seed lasts such a long time in the soil, control practices must be conducted continuously.

Noncrop Areas. In areas outside the landscape or orchard, cultivation and herbicide treatment can be used. If herbicides are to be used, treat the bindweed plants before they are drought stressed. Use a translocated herbicide, such as glyphosate or a combination of glyphosate and dicamba in areas where its use is allowed, at the flowering stage of growth. Addition of dicamba gives the treatment some soil residual activity that helps with control of new seedlings. Retreatments will be necessary to give control of both established plants and of seedlings. If possible, grow a competitive planting of other plants to reduce field bindweed growth.

TABLE 1. Summary of Herbicides[1] for Control of Field Bindweed

Site	Material	Applied to soil before seeds germinate	Applied to actively growing plants
Turfgrass	2,4-D	no	yes
	dicamba	no	yes
Ornamentals	glyphosate	no	yes
	oryzalin	yes	no
	pendimethalin	yes	no
	trifluralin	yes	no
Orchard/Vineyard	glyphosate	no	yes
	oryzalin	yes	no
Noncrop areas	dicamba	no	yes
	glyphosate	no	yes

[1]All materials listed are readily available for use by home gardeners.

REFERENCES

Mitich, L. W. 1991. Field bindweed. *Weed Tech.* 5:913-915.

Swan, D. G. and R. J. Chancellor. 1976. Regenerative capacity of field bindweed roots. *Weed Sci.* 24:306-308.

Weaver, S. E. and W. R. Riley. 1982. The biology of Canadian weeds. *Can. J. Plant Sci.* 62:461-472.

Yerkes, D., C. N. Weller, and S. C. Weller. 1996. Diluent volume influences susceptibility of field bindweed (*Convolvulus arvensis*) biotypes to glyphosate. *Weed Tech.* 10:565-569.

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Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits and/or vegetables ready to be picked.

Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse the containers. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Do not pour down sink or toilet. Consult your county agricultural commissioner for correct ways of disposing of excess pesticides. Never burn pesticide containers.

GREEN KYLLINGA

Integrated Pest Management for Home Gardeners and Landscape Professionals

Figure 1. Mature green kyllinga plant showing rhizome, roots, stem, and inflorescence.

Green kyllinga (*Kyllinga brevifolia)* is a weedy sedge that is becoming a major problem in turf and ornamental plantings in California. The genus *Kyllinga* consists of about 40 species that are distributed worldwide in subtropical and warm, temperate regions. Green kyllinga has been reported as a weedy problem from Florida across the southeastern United States into Arizona, California, and Hawaii. In California it occurs from San Diego in the south to the Sacramento Valley in the north. Green kyllinga is believed to have originated in Asia and was reported as a weed in California over 50 years ago. In the last few years, however, it has developed into a major problem for turfgrass and ornamental managers. Green kyllinga is often confused with yellow or purple nutsedge because it is similar in size and in the way it grows. However, the flower of the green kyllinga plant and the absence of underground tubers make it easy to distinguish from nutsedge.

IDENTIFICATION AND LIFE CYCLE

Green kyllinga (Fig. 1) is a perennial plant that grows best in moist or wet areas that receive full sun, but it can survive some shade and drying once established. Kyllinga grows well during the warm weather from April through October. It is dormant in winter but remains green in warm climates where freezing does not occur. When left unmowed, green kyllinga can reach a height of about 15 inches. In areas that are mowed, it grows in a prostrate manner, producing a network of numerous underground stems or rhizomes. It roots and sends out leaves at each stem node. If green kyllinga rhizomes are removed and chopped into pieces, new plants can be produced from each node or stem section.

Leaves are long and narrow, ranging from 1 to more than 5 inches in length. Flowering usually occurs from May to October, but it can occur earlier in warm locations. Flower stalks are triangular in cross section and 2 to 8 inches in length. The stalks terminate in a globular inflorescence (flower) that is green and about 3/8 inch in diameter (Fig. 2). Directly below the flower is a group of three leaves that radiate out from the stalk. There are 30 to 75 spikelets within each flower and each one is capable of producing one seed. A mature plant can produce over 100 flowers within a growing season and up to 5,000 seeds.

The seed of the green kyllinga plant is highly viable. It has an oval shape and is flat in cross section; it is about 1/8 inch long and 1/16 inch wide. Seed germination occurs at or very near the soil surface. Burying seed as little as 1/3 inch below the soil surface reduced germination 12-fold in one Arizona study. The tan-colored seed germinates when soil moisture is adequate and soil temperatures reach about 65°F. Germination continues throughout the summer. Seedling growth is slow initially and plants may require several weeks to become established. Once established, green kyllinga forms a vigorous system of rhizomes. It can survive and even flower and produce seed at mowing heights of 3/4 inch.

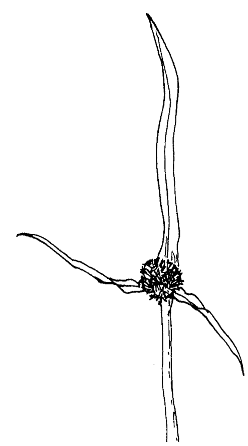

Figure 2. Seed heads of green kyllinga showing three subtending leaves on a short stem.

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IMPACT

Green kyllinga can be a major weed problem for turfgrass and ornamental managers. In turf it forms a weak sod that gives poor footing for athletic fields and golf courses. Although green kyllinga is most often a problem in bermudagrass, it has been found in cool season turf species as well. Green kyllinga has a texture and color that varies from normal turfgrass species and reduces the aesthetic quality of the turf. Also, green kyllinga grows faster than most turfgrass species, which gives infested turfgrass an undulating or irregular surface in as little as 2 days after mowing.

Once a few plants become established in turfgrass or ornamental areas, spread can be rapid. In warm weather, rhizomes can grow by more than 1 inch per day, forming thick mats in just a few weeks. Seed and rhizomes are spread by mowing, foot traffic, and cultivation. This allows the production of new plants and hastens spread.

MANAGEMENT

The primary method of control is to prevent new infestations. Thoroughly clean mowers and cultivation equipment before moving from infested to weed-free areas. If solitary plants of green kyllinga are found, they should be grubbed out (i.e., remove the entire plant, roots and all) and the area monitored for several months to make sure that removal was complete. When green kyllinga infests ornamental plantings it forms a dense mat that crowds out desirable species and reduces the vigor of those plants that survive. Because of the extensive rhizome system in established stands, hand-pulling or hoeing to remove green kyllinga is usually futile unless done repeatedly over a long period of time. Thus control by this means is very expensive and not always successful. Areas with infestations should be isolated until control can be accomplished. Turfgrass and ornamental areas should be well maintained to promote maximum vigor. This will aid in making these plantings as competitive as possible to slow invasion of the weed. Dense turfgrass and ornamentals will shade the soil surface making the establishment of green kyllinga seedlings difficult.

Turfgrass

No single control procedure has been successful in controlling green kyllinga in turfgrass.

Early grubbing of solitary infestations has been successful when practiced diligently. Spot-spraying isolated plants with glyphosate can be helpful, but the turfgrass is also killed, leaving open areas and making kyllinga reestablishment easier. The open spots should be overseeded to establish a vigorous turf.

Preemergent herbicides have been successful in limiting germination of green kyllinga seeds. These herbicides could be applied in spring before soil temperatures reach 60°F to limit germination in late spring and early summer. Preemergent materials that can be used by home gardeners include pendimethalin, bensulide, and benefin. Commercial applicators may also use prodiamine and dithiopyr.

Postemergent herbicides can limit growth of green kyllinga. For commercial applicators, best control has been obtained when halosulfuron has been applied in two applications spaced about 2 weeks apart. Multiple applications of MSMA will reduce infestations (at least three applications at 7- to 10-day intervals are needed). Bentazon has reduced green kyllinga growth when two applications were made about 2 weeks apart. Both MSMA and bentazon can be applied only by licensed pesticide applicators.

Ornamentals

There are few options for the control of green kyllinga in ornamental plantings. Prevention is very important. Hand-removal or spot-spraying of solitary plants will save time and money in the long run. Cultivation or hand-hoeing, although possible under some circumstances, is generally not useful and may be detrimental. Hoeing may break rhizomes into smaller pieces and "transplant" them to new areas. This is particularly true if irrigation follows hoeing. Geotextile mulches combined with hand-removal should provide adequate control in home gardens.

Mulching with landscape fabrics (geotextile mulches) can be effective if fabrics are overlapped and no light is allowed to penetrate to the soil. Use a polypropylene or polyester fabric or black polyethylene (plastic tarp) to block all plant growth. Wood chips or bark may be placed on top. Organic mulches alone may not effectively control kyllinga because it will probably grow through the mulch.

Preemergent herbicides such as oryzalin and pendimethalin can be used to limit seedling germination in sites where their use is permitted. Make applications in April before soil temperatures reach 60°F. Preemergent herbicides will be of little benefit if established kyllinga plants are already present.

Few postemergent herbicides are registered for use in established ornamental plantings. Spot treatment with glyphosate can reduce green kyllinga growth, but do not let the spray come in contact with desirable plants or injury will result.

REFERENCES

Bryson, C. T. et al. 1997. *Kyllinga*, A genus of neglected weeds in the continental United States. *Weed Tech.* 11(8):838–842.

Kawabata, O., R. K. Nishimoto, and C. Tang. 1994. Interference of two kyllinga species (*Kyllinga nemoralis* and *Kyllinga brevifolia*) on bermudagrass (*Cynodon dactylon*) growth. *Weed Tech.* 8(1):83–86.

Molin, W. T. et al. 1997. Green kyllinga (*Kyllinga brevifolia*): germination and herbicidal growth. *Weed Sci.* 45(4): 546–550.

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KIKUYUGRASS

Integrated Pest Management for Home Gardeners and Professional Horticulturalists

Figure 1. Kikuyugrass stolon showing rooting at nodes.

Kikuyugrass (*Pennisetum clandestinum*) is an extremely aggressive perennial weed of turfgrass, ornamental plantings, orchards, and noncrop areas in California. Native to Africa, kikuyugrass is well adapted to warm, temperate climates such as those of the coast and inland valleys of southern and central California. Kikuyugrass was originally imported to California around 1918 as a ground cover to reduce erosion on ditch banks. With its rapid stolon growth and thatch formation, it quickly moved from these sites and became a serious weed pest. In the past kikuyugrass was often confused with St. Augustinegrass and may have been mistakenly propagated and planted in its place.

IDENTIFICATION AND LIFE CYCLE

Kikuyugrass is a perennial grass that grows best under cool to warm temperatures (60° to 90°F) and moist conditions; however, it also survives well at high temperatures (100°F).

Like bermudagrass, kikuyugrass has a special photosynthetic pathway that allows it to assimilate carbohydrates at a high rate and to grow rapidly during periods of high light intensity and warm temperature. But, unlike bermudagrass, kikuyugrass is able to maintain its steady growth rate at lower temperatures. In coastal and some inland valley areas, kikuyugrass may not go dormant in winter. In other inland areas of California, it often turns brown in late November and remains dormant until February or March, depending on temperature. After kikuyugrass resumes growth in late spring, a rapid growth rate is reached by early summer and maintained through early fall. When growing rapidly, kikuyugrass is capable of sustained shoot growth rates exceeding 1 inch per day. Flowering begins in late spring and is stimulated by mowing. Seed production continues throughout summer and fall.

Kikuyugrass is a prostrate plant that spreads by producing a network of thick, fleshy stems (Fig. 1). These stems (stolons) often form a thick mat or thatch above the soil surface or a network of buried stems (rhizomes) from 1 to 4 inches deep in the soil. Carbohydrates are stored in the stems and can be utilized for regrowth after mowing or cultivation. If the stems are chopped into small pieces, each section is capable of producing new shoots and roots from its nodes. Thus kikuyugrass can easily be moved from one area to another on mowing and renovation equipment. Kikuyugrass, left unmowed, can attain a height of about 18 inches; it can also grow up over fences and into trees and shrubs. When mowed, kikuyugrass can survive cutting heights of less than 1/2 inch.

Leaves of kikuyugrass are light green in color and range in length from 1 to 10 inches. It has pointed leaf tips and flat leaf blades that are about 1/8 to 1/4 inch wide (Fig. 2). St. Augustinegrass, on the other hand, has rounded leaf tips with sharply folded or creased leaf blades. Another identifying characteristic of kikuyugrass is the

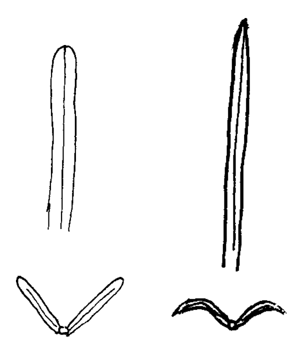

Figure 2. Top and side view of St. Augustinegrass (left) with folded blunt leaves compared to the flat, pointed leaves of kikuyugrass.

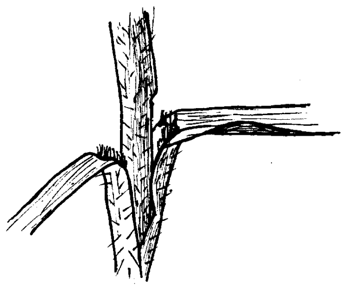

Figure 3. Kikuyugrass leaf with ridge of hairs at collar and hairs on leaf sheath and stem.

long fringe of hairs that parallels the stem in the leaf collar region (Fig. 3).

The pollen sacs or anthers (Fig. 4) extend above the turf surface on slender white filaments and give infested areas a whitish cast. The female portion of the flower (pistil) and seed are produced beneath the mowed surface of the turf; the seed is dark brown and about 1/8 inch in length with a rather large scar at its rounded base.

IMPACT

Kikuyugrass is a major weed problem in turfgrass and ornamental areas but can also be found in coastal and inland valley orchards of southern and central California. It causes physical, aesthetic, and competition problems. In turfgrass it forms thick mats that crowd out desirable species. The thick mat makes golf and other athletic uses difficult and in some cases dangerous. The light green color and coarse texture of kikuyugrass is not aesthetically desirable compared to other turf species. In golf courses it often invades greens and requires hand removal. In ornamental areas it invades ground covers and flower beds, often completely choking them out. Kikuyugrass can invade low-growing shrubs, blocking out light and reducing vigor. In orchards it can compete with trees for nutrients, interfere with irrigation by blocking sprinklers and emitters or drainage ditches, and overgrow fences.

MANAGEMENT

The best way to control kikuyugrass is to prevent its spread into new areas. Kikuyugrass can be spread both from seed and from stem sections and seems to be most commonly spread by mowing, cultivation, and renovation equipment. Clean equipment to remove any kikuyugrass seed or stem sections before moving it from infested areas. Kikuyugrass has also been spread in contaminated soil, sod, and planting stock. Make sure that any incoming materials are free of contamination. Maintain turfgrass and ornamental areas to assure they are at maximum vigor so that these plantings are as competitive as possible to help slow the invasion of this weed. Dense turfgrass and ornamental plantings shade the soil surface, making the establishment of kikuyugrass sprigs and seedlings more difficult. Vigorous, tall fescue varieties such as Olympic II or Jaguar II have been effective at reducing kikuyugrass invasion when used in the turfgrass. Regularly inspect orchards and noncrop areas for the presence of kikuyugrass and other invading weed species. Remove the invading species by hand or spot-treat them with an herbicide to prevent their spread.

Turfgrass

Kikuyugrass cannot be controlled with a single treatment or procedure in turfgrass. A vigorously growing turf coupled with early grubbing (removal of the entire plant, roots and all) of solitary infestations has been successful when practiced diligently. Spot-spraying isolated plants with glyphosate can be helpful but will also kill the turfgrass, leaving open areas in which kikuyugrass can easily reestablish itself. Overseed the open spots with the desired grass species to establish a vigorous turfgrass.

When they are applied in March, preemergent herbicides have been successful in limiting germination of kikuyugrass seeds in spring and early summer. Pendimethalin, bensulide, and benefin are available for use around the home; prodiamine is also available for use by commercial applicators. Because this weed spreads primarily by regrowth from stem sections, multiple applications of a postemergent herbicide are required to control established infestations. In cool-season turfgrass (tall fescue, perennial ryegrass, and Kentucky bluegrass) about three to four applications per year are necessary. Best control has been obtained from sequential applications of a combination of triclopyr and MSMA applied 4 to 6 weeks apart. Both available for use around the home. Sequential applications of either MSMA or triclopyr alone will reduce kikuyu-grass vigor and growth, but are not as effective as the combination. Sequential applications of fenoxaprop, which is available for use by professional pesticide applicators only, have also been effective in reducing kikuyugrass.

In bermudagrass turf, the only selective postemergent treatment option for reducing kikuyugrass invasion has been sequential applications of MSMA.

Ornamentals

There are few options for the control of kikuyugrass in ornamental plantings. Prevention is very important as is hand-removal or spot-spraying of solitary plants. Hand-weeding is the primary method of control in the home garden. Cultivation or hand-hoeing, although possible under some circumstances, is generally detrimental because it breaks rhizomes and transplants them to new areas. This is particularly true if irrigation follows hoeing.

Mulching with strong landscape fabric can be effective if it is overlapped and

Figure 4. Kikuyugrass anthers protruding from stem.

no light is allowed to penetrate to the soil. Use a polypropylene or polyester fabric or black polyethylene (plastic tarp) to block all plant growth. Organic mulches may not offer effective control of kikuyugrass because plants sprouting from rhizomes can grow through the mulch.

Preemergent herbicides such as oryzalin and pendimethalin, which are both available for use by home gardeners, can be used to limit the germination of seeds in sites where product labels allow their use. Apply preemergent herbicides in March before seeds germinate. Preemergent herbicides are of little benefit if established kikuyugrass is already present because these materials only prevent seed germination.

Use postemergent herbicides to control kikuyugrass in established ornamental plantings. Selective grass control herbicides reduce kikuyugrass growth in plantings where product labels allow their use. Sethoxydim and fluazifop are available for use by the home gardener; professional pesticide applicators may also use clethodim. Spot treatment with glyphosate kills kikuyugrass but do not allow the spray to get on desirable plants or injury will result. Application of glyphosate with a sponge applicator may allow more selectivity.

Orchards

Prevention is very effective as a control method in orchards. Hand-removal or spot treatment with glyphosate can be very cost-effective. Mulching with organic mulches will probably not be effective against this competitive perennial plant.

Most of the long-residual, soil-applied herbicides used in orchards will limit seed germination of kikuyugrass. The availability of these herbicides for use varies depending on the tree species; check product labels. Oryzalin and trifluralin limit root growth from kikuyugrass stem sections. Herbicides such as norflurazon and bromacil in citrus reduce established kikuyugrass infestations. These herbicides are available for use in commercial orchards only.

Postemergent treatments with glyphosate in summer and fall are very effective, but additional treatments may be necessary as new seedlings develop or new stem sections are brought in.

Noncrop

In noncrop areas kikuyugrass only grows where water is readily available, such as in ditchbanks. Discing kikuyugrass in these areas should be avoided because it may transplant and ultimately increase the kikuyugrass population. Residual soil-applied herbicides used in noncrop weed control will kill germinating kikuyugrass seedlings and limit growth of established kikuyugrass. Postemergent application of glyphosate either as a spot treatment or as a broadcast application controls established kikuyugrass.

REFERENCES

Cudney, D. W. et al. 1994. Herbicide program can control kikuyugrass in cool-season turf. *Calif. Agric*. 48(2): 24–28.

Cudney, D. W. et al. 1993. Kikuyugrass (*Pennisetum clandestinum*) management in turf. *Weed Tech*. 7(1):180–184.

Cudney, D. W. et al. 1982. Chemical and cultural control of kikuyugrass in turf. *Calif. Agric.* 36(1):4–5.

Elmore, C. L., V. A. Gibeault, and D. W. Cudney. 1997. Invasion resistance of tall fescue (*Festuca arundinaceae*) and perennial ryegrass (*Lolium perenne*) to kikuyugrass (*Pennisetum clandestinum*). *Weed Tech*. 11(1):24–29.

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MISTLETOE

Integrated Pest Management for Home Gardeners and Landscape Professionals

Broadleaf mistletoe *(Phoradendron macrophyllum)* is an evergreen parasitic plant that grows on a number of landscape tree species in California. Hosts of broadleaf mistletoe include alder, 'Aristocrat' flowering pear, ash, birch, box elder, cottonwood, locust, silver maple, walnut, and zelkova. Other species of broadleaf mistletoe in California include *P. villosum,* which infests only oaks, and *Viscum album,* which attacks alder, apple, black locust, cottonwood, and maple in Sonoma County only. Conifers are less often attacked by broadleaf mistletoes, but white fir (*Abies concolor*) is significantly infested in the southern Sierra Nevada mountain area. Dwarf mistletoes *(Arceuthobium* spp.) infest pines, firs, and other conifers in forests, and can be a problem in forest landscapes such as in the Sierra Nevada foothills.

IDENTIFICATION

Leafy mistletoes have green stems with thick leaves that are nearly oval in shape. Plants often develop a roundish form up to 2 feet or more in diameter. The small, sticky, whitish berries are produced from October to December. Evergreen clumps of mistletoe are readily observed on deciduous trees in winter when leaves are off the trees.

LIFE CYCLE AND BIOLOGY

Mistletoe plants are either female (produce berries) or male (produce only pollen) (Fig. 1). The berries of the female plant are small, sticky, and whitish; they are very attractive to birds such as cedar waxwings, robins, and others. The birds feed on and digest the pulp of the berries, excreting the living seeds that stick tightly to any branch on which they land. In most cases, the initial infestation occurs on larger or older trees because birds prefer to perch in the tops of taller trees. A heavy buildup of mistletoe often occurs within an infested tree because birds are attracted to the berries, and may spend a good deal of time feeding on them. In addition, seeds may fall from mistletoe plants in the upper part of the tree, creating new infestations on the lower branches. The rapidity with which mistletoe spreads is directly related to the proximity and severity of established infestations, and newly planted trees can be quickly infested if they are growing near old, heavily infested trees.

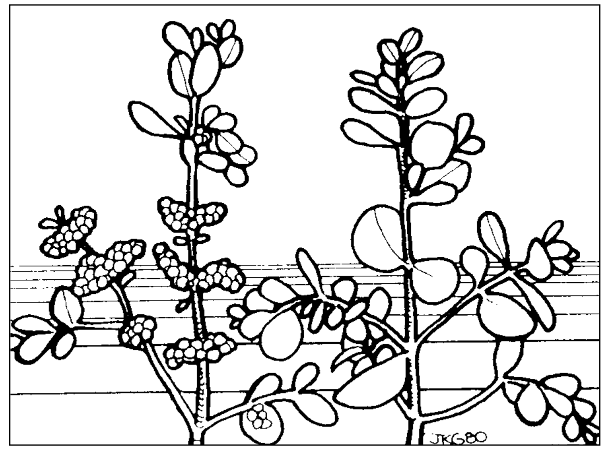

Figure 1. Only the female plant (left) produces berries.

After the mistletoe seed germinates, it grows through the bark and into the tree's water-conducting tissues, where rootlike structures called haustoria develop (Fig. 2). The haustoria gradually extend up and down within the branch as the mistletoe grows. Initially, the parasitic plant grows slowly; it may take years before the plant blooms and produces seed. Broadleaf mistletoes have succulent stems that become woody at the base. Old, mature mistletoe plants may be several feet in diameter, and on some host species, large swollen areas develop on the infected branches where the mistletoe penetrates. If the visible portion of the mistletoe is removed, new plants often resprout from the haustoria.

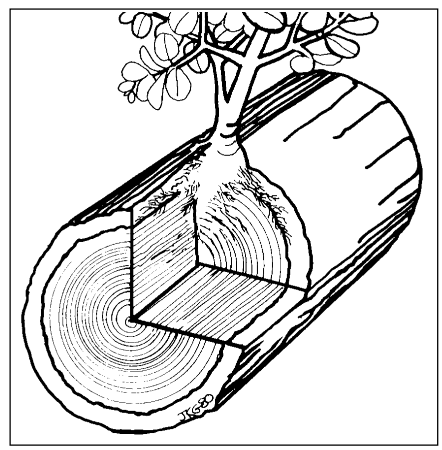

Figure 2. There is no distinct root for mistletoe, only fine threadlike haustoria.

Dwarf mistletoes are smaller plants than broadleaf mistletoes, with mature stems less than 6 to 8 inches long. Dwarf mistletoe shoots are nonwoody, segmented, and have small scalelike leaves. While broadleaf mistletoe seeds are dispersed by birds, dwarf mistletoe seeds are spread mostly by their forcible discharge from fruit, which can propel seeds horizontally into trees up to 30 to 40 feet away.

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DAMAGE

Broadleaf mistletoe absorbs both water and mineral nutrients from its host trees. Healthy trees can tolerate a few mistletoe branch infections, but individual branches may be weakened or sometimes killed. Heavily infested trees may be reduced in vigor, stunted, or even killed, especially if they are stressed by other problems such as drought or disease.

MANAGEMENT

In newly developed areas or in older established areas where trees are being replaced, the ideal method of controlling or preventing mistletoe is to plant trees believed to be resistant or moderately resistant to mistletoe. Avoid trees like Modesto ash, known to be especially susceptible to mistletoe infestation. Where many new trees are being planted, control mistletoe in any surrounding infected trees to reduce the infection of new trees.

For treatment of existing trees it is important to remove mistletoe before it produces seed and spreads to other limbs or trees. Mechanical control through pruning is the most effective method for removal. Growth regulators provide a degree of temporary control but repeated applications are required. Severely infested trees should be removed and replaced with less susceptible species to protect surrounding trees.

Mechanical Control

The most effective way to control mistletoe and prevent its spread is to prune out infected branches, if possible, as soon as the parasite appears. Using thinning-type pruning cuts, remove infected branches at their point of origin or back to large lateral branches. Infected branches need to be cut at least one foot below the point of mistletoe attachment in order to completely remove embedded haustoria. Done properly, limb removal for mistletoe control can maintain or even improve tree structure. Severe heading (topping) is often used to remove heavy tree infestations; however, such pruning weakens a tree's structure, and destroys its natural form. In some cases it is best to remove severely infested trees entirely because they are usually a source of mistletoe seed.

Mistletoes infecting a major branch or the trunk where it cannot be pruned may be controlled by cutting off the mistletoe flush with the limb or trunk. Then wrap the area with a few layers of wide, black polyethylene to exclude light. Use twine or tape to secure the plastic to the limb, but do not wrap it too tightly or the branch may be damaged. In some tree species callus tissue will form under the plastic, further weakening the limb. Broadleaf mistletoe requires light and will die within a couple of years without it. It may be necessary to repeat this treatment, especially if the wrapping becomes detached or if the mistletoe does not die.

Simply cutting the mistletoe out of an infested tree each winter, even without wrapping, is better than doing nothing at all. Even though the parasite will grow back (Fig. 3), spread is reduced because broadleaf mistletoe must be several years old before it can bloom and produce seed.

Chemical Control

The plant growth regulator ethephon (Monterey Florel brand) may be used as directed by the label to control mistletoe in *dormant* host trees. To be effective, the mistletoe must also be dormant and the spray must thoroughly wet the mistletoe foliage. Mistletoe comes out of dormancy before most trees, so the ideal time to treat is from November 1 through the end of January. By treating when trees are dormant, the tree foliage will not get in the way of the treatment and the mistletoe clumps are more visible than when leaves are on the tree. Spraying provides only temporary control, especially on well-established infestations, by causing some of the mistletoe plant to fall off. The mistletoe will soon regrow at the same point, requiring retreatment.

Resistant Species

Some tree species appear resistant to broadleaf mistletoe. Bradford flowering pear, Chinese pistache, crape myrtle, eucalyptus, ginkgo, golden rain tree, liquidambar, sycamore, and conifers such as redwood and cedar are rarely infested. These or other resistant species should be considered when planting in infested areas, or when replacing infested trees.

Integrated Pest Management in a Community

An effective mistletoe control program in a community requires a combination of methods and the cooperation of developers, homeowners, businesses, and public agencies. Property owners can substantially reduce mistletoe infestations in their own trees, but without community cooperation, infestations will recur. Public wooded areas, such as parks and stream banks adjacent to urban areas, can be a continual source of seed and, therefore, mistletoe infestation. For this reason, the planting of tree species not susceptible to mistletoe infestation should be a part of every city and park plan.

The most drastic and possibly the best control measure is to remove severely infested trees and replace them with less susceptible species. Economically,

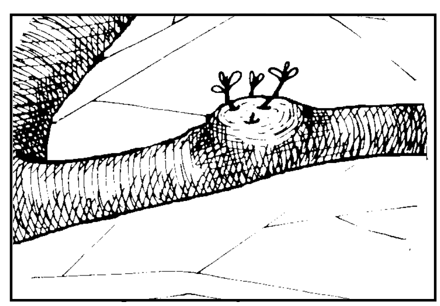

Figure 3. Mistletoe resprouts after being cut back.

tree removal could be a practical approach for both public agencies and landowners, in addition to providing a source of firewood. To assist citizens in removing mistletoe from less severely infested trees on their property, some cities loan removal tools. In other cases, neighborhood residents may pool resources to hire a tree service to remove all mistletoe in their neighborhood.

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Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

NUTSEDGE

Integrated Pest Management for Home Gardeners and Landscape Professionals

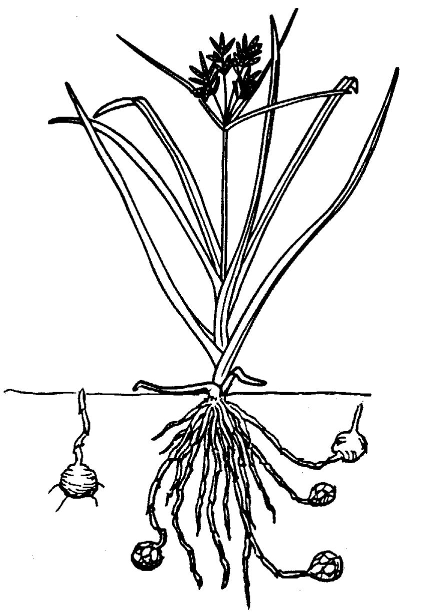

Figure 1. Yellow nutsedge.

Nutsedges are common weeds in landscapes and gardens in the coastal valleys, Central Valley, and southern areas of California. They thrive in water-logged soil and their presence often indicates that drainage is poor, irrigation is too frequent, or sprinklers are leaky. Once established, however, they will tolerate normal irrigation conditions or drought. The two most common species of nutsedge in California are yellow nutsedge (*Cyperus esculentu*) (Fig.1) and purple nutsedge (*C. rotundus*) (Fig. 2). Yellow nutsedge is found throughout California, whereas purple nutsedge is found mostly in the southern portions of the state.

IDENTIFICATION

Although nutsedges are often referred to as "nutgrass" and resemble grasses, they are not grasses but true sedges. Their leaves are thicker and stiffer than most grasses and are arranged in sets of three at the base, whereas grass leaves are opposite in sets of two. Nutsedge stems are solid, and when looked at in cross-section, they are triangular; grass stems are hollow and round, and in cross-section they are almost flat or oval. Nutsedge has three long, leaf-like bracts at the base of each flower head. Yellow nutsedge has light brown flowers and seed, and purple nutsedge flowers have a reddish tinge and the seed are dark brown or black.

Yellow and purple nutsedges produce tubers, which are incorrectly called "nuts" or "nutlets," thus the origin of its common name. These tubers are produced on rhizomes (underground stems) that grow as deep as 8 to 14 inches below the soil surface. Buds on the tubers sprout and grow to form new plants; thus individual nutsedge plants eventually form patches that can range up to 10 feet or more in diameter. Yellow nutsedge produces round, smooth, brown or black tubers that are about 1/2 inch at maturity. Only one tuber is formed at the end of a rhizome. Tubers of a yellow nutsedge plant have a pleasant almond taste. Tubers of purple nutsedge plants are covered with red or red-brown scales and are formed in chains with several tubers on a single rhizome. These tubers are bitter to the taste.

Be careful not to confuse yellow or purple nutsedge with tall umbrella sedge (*C. eragrostis*) (Fig. 3), another perennial sedge that is found in wet, soggy soils. Tall umbrella sedge is a large, light green sedge that does not produce tubers. It spreads by seed or by new plants that form on short, thick rhizomes around the base of the mother plant. If left unmowed, it grows taller than yellow nutsedge, but in a mowed turf it can be distinguished from yellow nutsedge by its wider leaves and stems, its short, thick rhizomes, its lack of tubers, and its tendency to grow in tight clumps that are less than 1 foot in diameter.

Another weed often confused with nutsedges is green kyllinga (*Kyllinga*

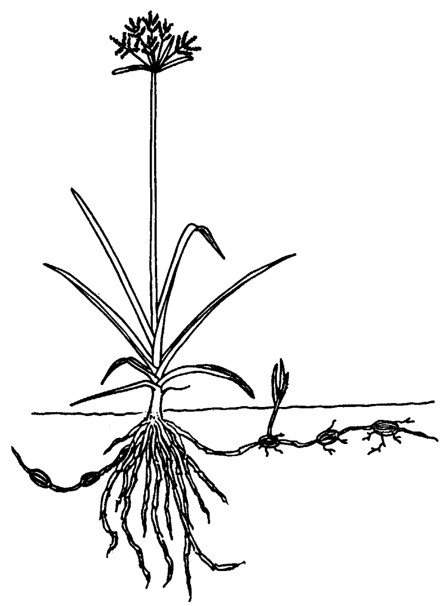

Figure 2. Purple nutsedge.

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Figure 3. Tall umbrella sedge.

brevifolia) (Fig. 4), which is also a major problem in turf and ornamental plantings (see *UC IPM Pest Notes: Green Kyllinga,* Publication 7459). The flower of green kyllinga is visibly different from that of nutsedge, and the plant does not produce tubers.

LIFE CYCLE

Yellow and purple nutsedges are perennial plants. Their leaves and flowering stalks generally die back in fall when temperatures decrease, but tubers and rhizomes survive in the soil and sprout the following spring when soil temperatures remain above 43°F for yellow nutsedge or above 59°F for purple nutsedge. The majority of tubers can be found in the top 6 inches of soil where they can survive for 1 to 3 years. In field crops, research indicates that most plants sprout from tubers, and seed do not contribute much to the spread of nutsedge; however, no work has been done to examine the role of seed in the spread of nutsedge in the landscape.

DAMAGE

Nutsedges are a problem in the lawn because they grow faster, have a more upright growth habit, and are lighter green in color than most grass species, resulting in a nonuniform turf. In gardens and landscapes, nutsedges will emerge through mulches in shrub plantings and vegetable and flower beds throughout the growing season.

MANAGEMENT

Tubers are key to perennial nutsedges' survival. If you can limit production of the tubers, then the nutsedge will eventually be controlled. To limit tuber production, remove small nutsedge plants before they have five to six leaves; in summer this is about every 2 to 3 weeks. Up to this stage, new tubers have not yet formed. By removing as much of the plant as possible, the tuber will be forced to produce a new plant, drawing its energy reserves from tuber production to the production of new leaves. Continually removing shoots eventually depletes the energy reserves in the tuber because 60% of the reserves are used to develop the first plant and 20% for the second. However, mature tubers can resprout as many as 10 to 12 times. Even though these newer sprouts start out weaker than the previous ones, they will gradually resupply the tuber's energy reserves unless they are removed.

The best way to remove small plants is to pull them up by hand or to hand-hoe. If you hoe, be sure to dig deeply (8 inches) to remove the whole plant. Using a tiller to destroy plants will only spread the infestation, because it moves the tubers around in the soil. However, repeated tillings of small areas before the plants have six leaves will reduce populations. Many people mistakenly use systemic herbicides such as glyphosate to try to kill the tubers after the plant is fully grown. Unfortunately, when tubers are mature there is little translocation of the herbicide from the leaves to the tubers, thus tubers are not affected.

If nutsedge is found in small patches in turf, it may be best to dig out the patch to about 8 inches deep, refill, and then seed or sod the patch.

Biological control of nutsedge using insects and plant pathogens has been researched, but as of yet has not provided consistent control. An unexpected control of nutsedge may come from sweet potato tissue. Sweet potato tissue has been shown to contain chemicals that suppress the growth of nutsedge roots, but no one has yet isolated the chemical that is responsible for this effect.

In addition to consistently removing the small plants, nutsedge populations can be reduced by shading, drying, mulching, and with properly timed applications of herbicides.

Drying

During the middle of the summer, purple nutsedge can be controlled by cultivating the infested area and then withholding all moisture to allow the sun to dry the tubers. Repeated tilling and drying is required to give good control. This method is only effective in areas where other plants do not need irrigation. Drying is not effective for the control of yellow nutsedge.

Shading

Nutsedges do not grow well in shade. By changing landscape plantings you

Figure 4. Green kyllinga.

may be able to reduce their growth with shade. For example, a highly infested, annually planted flower bed may be better off replanted with a tall, dense, ground cover or shrub that would shade out the nutsedge. Low-growing ground covers will not shade out yellow nutsedge.

Mulching

The commonly used black polyethylene mulches do not control yellow or purple nutsedge because the sharp points at the ends of the leaves can penetrate them. Newer landscape fabrics made from polypropylene polymers are available that effectively suppress nutsedge growth (see Table 1) and have the added benefit of being water and air permeable, unlike polyethylene. If the planting permits, mulching with a landscape fabric, with or without an organic mulch on top, will suppress nutsedge growth. For complete control, however, you will still need to remove any emerging nutsedge plants.

Chemical Control

Few herbicides have been effective in controlling nutsedge, either because of lack of selectivity to other plants or lack of uptake. Apply herbicides when they will be most effective (Table 2). Postemergent (nonselective) herbicides that are currently available to help control nutsedge in the home landscape include pelargonic acid (Scythe), MSMA, and glyphosate (Roundup). These herbicides require repeated application and their use will only result in limited suppression of these weeds. MSMA is more effective on yellow than purple nutsedge.

TABLE 1. Effectiveness of Landscape Fabrics in Suppressing Emergence of Yellow Nutsedge.

Landscape fabric	Number of shoots penetrating fabric after 30 days in greenhouse
Dupont Typar 307	0.0
Dupont Typar 312	0.0
Weed Barrier Mat	0.3
Geoscape Landscape Fabric	0.8
Dewitt Pro 5	1.0
Weedblock Fabric	1.8
Amoco Rid-a-Weed	2.5
Phillips Duon Fiber	3.3
Control	8.3

Adapted from C. A. Martin, H. G. Ponder, and C. H. Gilliam. 1991. Evaluation of landscape fabrics in suppressing growth of weed species. *J. Environ. Hort.* 9:38-40.

TABLE 2. Controlling Nutsedge with Chemicals.

Herbicide	Commercial name	Apply before seed germinates	Apply to young plant	Readily available to home gardener
dichlobenil	Casoron, Norosac	yes	no	yes
EPTC	Eptam	yes	no	yes
glyphosate	Roundup	no	yes	yes
halosulfuron	Manage	no	yes	no
metolachlor	Pennant	yes	no	no
MSMA (crabgrass and nutsedge control)		no	yes	yes
pelargonic acid	Scythe	no	yes	yes

A postemergent herbicide that has some selectivity, particularly in turf, is halosulfuron (Manage). This is a rapidly translocated herbicide, but to be effective, this and other postemergent herbicides must be applied to nutsedges before the fifth leaf stage, when the plant is still building its energy reserves in the tubers by translocating from the leaves to the newly forming tubers. After this stage, translocation to the tubers slows down or ceases and the herbicide will only kill the aboveground portion of the plant, leaving the tubers unaffected.

Apply glyphosate when the plants are actively growing and have not been recently mowed or cut. Be sure to read the label and determine how much time after application before an irrigation can be applied. Do not apply if rainfall is expected within 24 hours of application. Glyphosate works most quickly when the weather is warm and sunny. Activity may be delayed if it is cool or cloudy following application. MSMA is also translocated and must be applied to actively growing plants younger than the fifth-leaf stage. Pelargonic acid is also most effective when applied on a warm, sunny day. This chemical will not be affected by rain 2 hours after spraying. Because pelargonic acid does not move through the plant, you need to thoroughly cover the entire aboveground portion of the plant with spray to kill it. Do not spray either herbicide when it is windy or other plants may be injured from the spray drift. Halosulfuron is used in such minute amounts that the manufacturer markets it in premeasured, water-soluble bags. Follow all label directions for optimal control of nutsedge, and be sure to add a nonionic surfactant to the spray solution.

Preemergent herbicides available to reduce yellow nutsedge include dichlobenil (Casoron, Norosac), EPTC (Eptam), and metolachlor (Pennant). Of these, metolachlor is more effective than EPTC and safer around many ornamentals than dichlobenil, but it must be applied by a licensed pesticide applicator. No preemergent herbicides can be used on turfgrass but they can be used on selected ornamental plants. Read the label directions to see which ornamentals will tolerate each herbicide. Metolachlor and EPTC must be incorporated mechanically 3 to 4 inches to place the herbicide in the soil so yellow nutsedge will take up the chemical through the shoot as it emerges. The use of preemergent herbicides reduces the number of emerging nutsedge plants, but for long-term control, retreatment is necessary.

REFERENCES

Dreistadt, S.H., J. K. Clark, and M. L. Flint. 1994. *Pests of Landscape Trees and Shrubs: An Integrated Pest Management Guide*. Oakland: Univ. Calif. Agric. and Nat. Resources, Publication 3359.

Flint, M.L. 1998. *Pests of the Garden and Small Farm: A Grower's Guide to Using Less Pesticide*, 2nd ed. Oakland: Univ. Calif. Agric. and Nat. Resources, Publication 3332.

Grower's Weed Identification Handbook. 1978 to present. Oakland: Univ. Calif. Agric. and Nat. Resources, Publication 4030.

Principles of Weed Control in California. 1985. Fresno: Thomson Publications, 474 pp.

Whitson, T.D., et al. 1991. *Weeds of the West*. Jackson: Univ. Wyoming, 630 pp.

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SPOTTED SPURGE

Integrated Pest Management for Landscape Professionals, Citrus Growers, the Container-grown Ornamental Industry, and Home Gardeners

Spotted spurge, *Euphorbia* (=*Chamaesyce*) *maculata*, is an annual species that is native to the eastern United States. It is common throughout California and has become a serious weed in many crops including citrus, turf, ornamental beds, and container ornamentals.

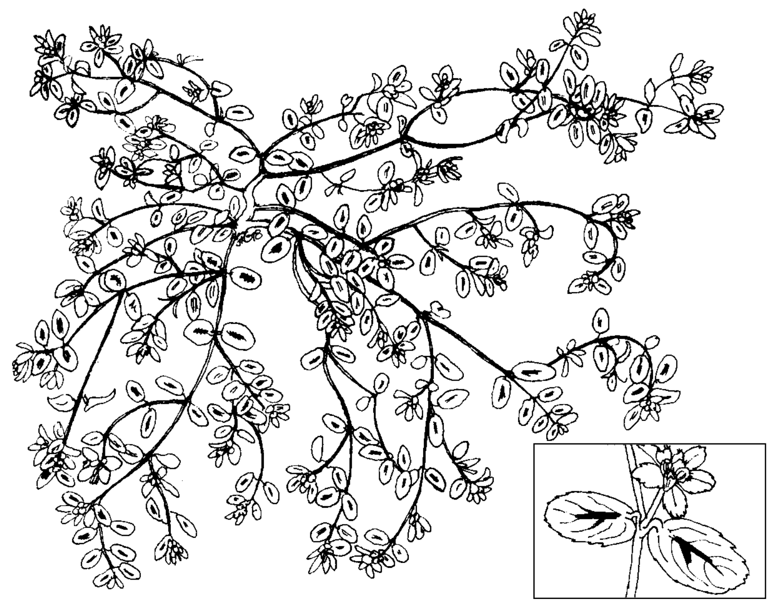

Figure 1. Top view of spotted spurge (*inset:* closeup of leaves and flower).

IDENTIFICATION

Spotted spurge is a low-growing annual plant that often forms a dense mat (Fig. 1). It has dark green, opposite leaves that are ⅛ to ½ inch long and about ⅛ inch wide. Leaves are usually marked with a red spot midway down the center leaf vein. Each leaf has a short stem (petiole) with a separate stipule, or little scalelike appendage at its base; you may need a 10X hand lens to see the stipule. The stem, when broken, exudes a milky latex juice. The plant has a central taproot system that is capable of extending more than 2 feet into the soil. The tiny, pinkish flowers consist of only stamens and pistils and are grouped in small flowerlike cups (cyathia) in the leaf axils. The fruit is a three-celled seed capsule that is 1/16 inch long or less. Each cell contains one seed that is about 1/25 inch long.

Although spotted spurge is the major spurge weed in California, there are six other species of spurges that appear regularly as weeds in the state: garden spurge (*E. hirta*); nodding spurge *(E. nutans)*; ground spurge (*E. prostrata)*; creeping spurge (*E. serpens*); petty spurge (*E. peplus*); and thyme-leafed spurge (*E. serpyllifolia)*. Ground spurge and creeping spurge are both widespread and troublesome weeds in California; petty spurge is a problem in southern California landscapes; and garden spurge, nodding spurge, and thyme-leafed spurge are much less frequently the source of problems. In addition to these weed species there are 17 native species of spurge that occur in arid plant communities. A few individuals of some of these native species may appear at the margins of cultivated areas adjacent to wildlands, but they are poorly adapted to cultivated conditions and rarely occur as weeds.

The plant key in this *Pest Note* (Table 1) is provided to identify all the spurges commonly encountered as weeds in California. Any weedy spurge that does not appear to fit the characteristics described in this key may be keyed using *The Jepson Manual,* listed in "References," or may be pressed and sent to the third author (address on last page) for identification. Unidentifiable plants may be either native species not treated here or newly introduced weeds such as garden spurge, which has only very recently been detected in the state.

IMPACT

Spotted spurge can become established in horticultural, agricultural, and noncrop sites. It overgrows turf and low-growing ground covers; invades open areas in gardens and landscapes; and can grow in sidewalk cracks. Spotted spurge is often found in citrus groves where it is tolerant of the herbicides commonly used for weed control in citrus. In addition to reducing the

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Table 1. A Key to the Weedy Spurges of California.

- ◆ flowers (cyathia) in dense axillary or terminal clusters (gen. > 10 cyathia per cluster)
  - ❍ stems erect, to 3 ft tall, sparsely hairy .... NODDING SPURGE (*Euphorbia nutans* Lagasca)
  - ❍ stems prostrate, with numerous spreading hairs .... GARDEN SPURGE (*E. hirta* L.)
- ◆ flowers (cyathia) solitary or paired in leaf axils (note: since leaves are opposite there will be a 2 to 4 cyathia in close proximity)
  - ❍ cyathia, fruit, stem and leaves hairy
    - ● fruit very sparsely hairy, 1.5–2 mm long; seeds 1–1.25 mm long, wrinkled with low rounded ridges; leaves lacking reddish central spot (rare form) .... THYME-LEAFED SPURGE (*E. serpyllifolia* Persoon)
    - ● fruit distinctly hairy; < 1.5 mm long; seed generally < 1 mm, cross-ridge with narrow sharp ridges, or wrinkled; if wrinkled, leaves usually with reddish central spot (very common species)
      -  seeds cross-wrinkled; fruit with appressed hairs over whole surface; leaves generally (> 95% of plants) with a reddish central spot .... SPOTTED SPURGE (*E. maculata* L.)
      -  seeds cross-ridged; fruit spreading hairy, mostly on edges only; leaves never with reddish central spot .... GROUND SPURGE (*E. prostrata* Aiton)
  - ❍ cyathia, fruit, stem and leaves hairless
    - ● stipules (appendages at leaf base) united into a whitish scale between the leaves; stems almost always rooting at the nodes; leaf margins smooth-edged or faintly toothed .... CREEPING SPURGE (*E. serpens* Kunth)
    - ● stipules separate and hairlike; stems rarely or never rooting at the nodes; leaf margins distinctly toothed, at least near the tip .... THYME-LEAFED SPURGE (*E. serpyllifolia* Persoon)

growth of desirable species, spotted spurge reduces uniformity and quality of turf, provides habitat for undesirable insects in citrus, serves as an intermediate host for fungal diseases of cultivated crops, and attracts ants with its seed.

Spotted spurge is poisonous and has been known to cause death when sheep graze pastures where it is the predominant weed. Sheep that consumed as little as 0.62% of their body weight of spotted spurge have died within a few hours.

BIOLOGY

Spotted spurge is a summer annual that does not like competition and depends on its prolific seed production for survival. A single plant is capable of producing several thousand seeds. Seeds are small and can remain dormant in the soil until conditions are suitable for germination. Seeds that are produced in summer germinate readily whereas those produced in late fall are mostly dormant and won't germinate until spring. Spotted spurge germinates best when temperatures are between 75° and 85°F, but germination can occur at temperatures as low as 60°F and as high as 100°F. Thus, when moisture is available, germination can occur from February through September in most areas of California. Light is also required for maximum germination; seeds buried deeper than ½ inch will not germinate well. Plants that germinate early in spring under cool conditions may remain as small seedlings until temperatures are more desirable for growth. Once the seed germinates, a small rosette of leaves develops. As growth continues, the leaves form a dense mat that can grow up to 3 feet in diameter. Reproductive growth is rapid and seeds can be produced as soon as 5 weeks after germination.

MANAGEMENT

The primary method of managing spotted spurge should be prevention—it is very difficult to control this weed once it is established. Avoid bringing spotted spurge seeds into uninfested areas: use weed-free planting seed and uncontaminated planting stock. Clean machinery (lawn mowers) and workers' clothing to remove any weed seeds that might be present. Infested areas must be constantly monitored to cultivate or hand-pull new plants before they produce seed. Plants that are hand-pulled often break at the stem, leaving the root and several buds or a single stem from which regrowth is possible. Germination can be reduced if it is possible to bury the seeds or add a layer of mulch to cover them. When mulching, put at least 1 inch of a fine mulch or 3 inches of a coarse mulch (bark, etc.) on the soil surface. Be careful that seeds do not get on top of the mulch or they will germinate and grow there. Before planting areas to turf or ornamentals, soil solarization (covering the soil with sheets of clear plastic for 5 to 6 weeks during the summer) may be an effective method of reducing the viable seed population in areas where summer temperatures are hot (90°F or higher).

Turf

One of the best control measures for spotted spurge in turf is to maintain a competitive stand of grass. Where open areas develop in the turf either from stress, disease, insects, or abuse, light is able to penetrate to the soil surface, allowing spotted spurge to germinate. Once spotted spurge is established, altering cultural practices (mowing height, fertilization or irrigation) will not control it, but raising the mowing height in tall fescue or perennial ryegrass to 2 inches or more may reduce initial invasions.

Preemergent herbicides are helpful in reducing establishment of spotted spurge if they are applied in late winter before weed seeds germinate. Check the soil temperature to make sure the herbicides are applied before soil temperature at 1 inch exceeds 55° to 60°F. Preemergent herbicides for spurge in turf include pendimethalin (Pendulum), isoxaben (Gallery), DCPA (Dacthal), oxadiazon (Ronstar), and dithiopyr (Dimension); of these herbicides, only pendimethalin, dithiopyr, and isoxaben are available for use by the home gardener. Combination products are also available for both the home gardener and professional landscaper; examples include trifluralin plus benefin and oryzalin plus benefin.

Two postemergent contact herbicides, bromoxynil (available for commercial use only) and glufosinate (available for both commercial and home landscape use), can be applied to spotted spurge plants to reduce populations.

Container-grown Ornamentals and Ornamental Beds

Hand-pull spotted spurge plants from containers or ornamental beds. There are no selective herbicides that will control spurge once it is established. If planting new containers, be sure to use sterilized or weed-free planting mix. When purchasing container plants or stock for ornamental beds, avoid those with spotted spurge infestations. Preemergent herbicides will control spotted spurge if applied before emergence of the weed. These herbicides include pendimethalin, oryzalin, oxadiazon, prodiamine, and isoxaben (only oryzalin is available for home garden use). Combinations of herbicides are also available: oryzalin plus benefin, which can be used on ornamental beds but not for container-grown plants by both the home gardener and professional landscaper, and isoxaben plus trifluralin, which is available for professional use only. Mulches can effectively limit spotted spurge if they prevent light from reaching the seed. Hand-pull seedlings that escape preemergent herbicide treatment or germinate on the surface of mulches before they mature and produce seed.

Citrus

Spotted spurge is not controlled by the preemergent herbicides commonly used in commercial citrus orchards. It grows around drip emitters and low volume emitters and provides a habitat for insects that clog the emitters. Cultivation is not a viable option for control in citrus as it disturbs the shallow root system of the citrus, but a shallow scraping of the soil with a shuffle hoe may provide control. Spot treatments with the postemergent herbicide glyphosate can remove infestations, but retreatment is usually necessary every 6 to 8 weeks during the growing season. Preemergent treatment with oryzalin is helpful if it is applied in late winter before spotted spurge seeds germinate.

REFERENCES

Derr, J. F. 1994. Weed control in container-grown herbaceous perennials. *Hort. Sci.* 29 (2):95–97.

Elmore, C. L., J. J. Stapleton, C. E. Bell, and J. E. DeVay. 1997. *Soil Solarization: A Nonchemical Method for Controlling Diseases, Nematodes, and Weeds*. Oakland: Univ. Calif. Agric. Nat. Res. Leaflet 21377.

Elmore, C. L., and J. A. Roncorni. 1986. Postemergent control of *Euphorbia maculata* (spotted spurge). *West. Soc. Weed Sci. Res. Prog. Rep*. p. 84.

Koutnik, D. L. 1993. Chamaesyce. In J. C. Hickman, ed. *The Jepson Manual: Higher Plants of California.* Berkeley: Univ. Calif. Press.

Krueger, R. R., and D. L. Shaner. 1982. Germination and establishment of spotted spurge *(Euphorbia supina). Weed Sci.* 30:286-290.

Whitson, T. D. et al. 1996. *Weeds of the West.* Jackson: Univ. Wyoming. 630 pp.

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

YELLOW STARTHISTLE

Integrated Pest Management for Land Managers, Landscape Professionals, and Home Gardeners

Yellow starthistle

Yellow starthistle, *Centaurea solstitialis*, is native to Eurasia and was introduced to California around 1850 via South America. It is now common in open areas on roadsides, rangeland, wildlands, hay fields, pastures, and waste areas. Recent reports indicate that yellow starthistle infests between 10 and 15 million acres in California. The disturbance created by cultivation, poorly timed mowing, road building and maintenance, or overgrazing favors this rapid colonizer. It forms dense infestations and rapidly depletes soil moisture, thus preventing the establishment of other species. It is also poisonous to horses, causing a nervous disorder called "chewing disease" (nigropallidal encephalomalacia) that is fatal once symptoms develop. Horses are the only animal known to be affected in this manner and should not be allowed to graze on yellow starthistle.

IDENTIFICATION

Yellow starthistle is a gray-green to blue-green plant with a deep vigorous taproot. It produces bright, thistlelike yellow flowers with sharp spines surrounding the base. Yellow starthistle grows to heights varying from 6 inches to 5 feet. The stems of mature plants are rigid, spreading, and typically branching from the base in open areas. Stems and leaves are covered with a loose, cottony wool that gives them a whitish appearance. Stems appear winged due to leaf bases that extend beyond the nodes. Basal leaves are 2 to 3 inches long and deeply lobed. Upper leaves are short (0.5 to 1 inch long) and narrow with few lobes.

BIOLOGY

Yellow starthistle is a long-lived winter annual that is usually found below 6,000 feet elevation in dry, light-intensive areas where average annual rainfall is between 10 and 60 inches. Seed output can be as high at 30,000 seeds per square meter, with about 95% of the seed being viable soon after dispersal. Most seeds germinate within a year of dispersal, but some can remain viable in the soil for more than 3 years.

Yellow starthistle seeds germinate from fall through spring, which corresponds to the normal rainy season in California. After germinating, the plant initially allocates most of its resources to root growth. By late spring, roots can extend over 3 feet into the soil profile, although the portion above ground is a relatively small basal rosette. This allows yellow starthistle to out-compete shallow-rooted annual species during the drier summer months when moisture availability is limited near the soil surface. It also helps explain why yellow starthistle survives well into the summer, long after other annual species have dried up, and why it can regrow after top removal from mowing or grazing.

The competitive ability of yellow starthistle also depends on light intensity at the soil surface during the seedling and rosette stages of development. Yellow starthistle proliferates at high light intensity and does poorly in low light. High light conditions often occur along roadsides, in disturbed sites, grasslands, and on south-facing slopes at higher elevations.

MANAGEMENT

Control of yellow starthistle cannot be accomplished with a single treatment or in a single year. Effective management requires control of the current population and suppression of seed production, combined with establishment of competitive, desirable vegetation.

Prevention

Yellow starthistle proliferates along roadsides. Invasion by this weed may be increased with the disturbance created by road building and maintenance. Seeds are often spread by vehicles or with the transportation of livestock or contaminated soil. Survey roadsides for the presence of this

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weed and immediately control new infestations to prevent its seed production and subsequent spread.

Yellow starthistle also can be spread as a contaminant in grass seed. Only certified seed should be used for range or pasture seeding. Seed may also come as a contaminant in all classes of hay, particularly grass hay. Carefully check hay shipments for evidence of yellow starthistle. Hay used as mulch along roadsides or disturbed areas can be a source of yellow starthistle introduction. When feeding hay is suspected of containing yellow starthistle, place bales in one area and periodically check around feeding areas for signs of starthistle seedlings. Livestock that have fed in yellow starthistle-infested areas should not be pastured or shipped to uninfested areas. Control newly emerged seedlings to prevent establishment. It is important to control new infestations when they are small because spot eradication is least expensive and most effective at this time.

Biological Control

Five natural enemies of yellow starthistle have been imported from Europe and are well established in California as of 1998. These biological control agents include two weevils *(Bangasternus orientalis* and *Eustenopus villosus)* and three flies *(Urophora sirunaseva, Chaetorellia australis,* and *Chaetorellia succinea)*. They all attack the flower/seed head and directly or indirectly reduce seed production, the only means of reproduction and spread of the weed. The insects lay their eggs in, on, or near flower/seed heads and complete their development within them. *Eustenopus villosus* adults also directly reduce seed production by feeding on immature flower heads. All of these insects are highly host-specific to yellow starthistle and do not attack commercially valuable crops or native plants.

Following release of these natural enemies, protect the release area from practices that may damage the insects. Such practices include insecticide applications, soil cultivation, summer-prescribed burning, or mowing when the plants are in the flowering stage. After establishment, the insects are capable of building up to high numbers and spreading on their own. These insects do best in areas with warm, dry summer climates.

It is too early to know the impact of these natural enemies on yellow starthistle in California. It will likely take a long time to achieve effective biological control. The insects become more numerous and thus more available with each succeeding year. The most recent releases, *Eustenopus villosus* and *Chaetorellia succinea,* have proven to be the most effective agents for yellow starthistle seed suppression. These insects are becoming more widespread throughout the state. Land owners and managers with yellow starthistle problems may contact their County Department of Agriculture about obtaining these biological control insects.

These biocontrol agents reduce seed production, slowing spread of the weed. Biocontrol of established populations is uncertain until impact data are available, but even if successful, biological control requires years to achieve. It is possible that a combination of herbicides and biocontrol will provide more sustainable control than either technique used alone.

Cultural Control

Yellow starthistle begins emergence with fall rains and continues to germinate throughout the rainy season. A single cultivation effectively controls seedlings and rosettes of yellow starthistle after the rainy season when soils are dry. This treatment must be made before seeds are produced. In contrast, if cultivations are made during spring, repeated treatments are needed to control each new flush of seedlings.

Mowing can be used to manage yellow starthistle, provided it is well-timed and used on plants with a high branching pattern. Mowing early growth stages results in increased light penetration and rapid regrowth of the weed. If plants branch from near the base, regrowth will occur from recovering branches. Repeated mowing of plants too early in its life cycle (rosette or bolting stages) or when branches are below the mowing height will not prevent seed production, as flowers will develop below the mower cutting height. Plants with a high branching pattern are easier to control, as recovery will be greatly reduced. Even plants with this growth pattern must be mowed in the late spiny or early flowering stage to be successful. An additional mowing may be necessary in some cases.

To encourage growth of desirable vegetation, let these species set seed before mowing, but be sure to mow well before starthistle is in full flower. In general, mowing is most effective when soil moisture is low and no irrigation or rainfall follows mowing.

Grazing is effective in reducing yellow starthistle seed production. Sheep, goats, or cattle eat yellow starthistle before spines form on the plant. Goats will eat starthistle even in the spiny stage. The plant's crude protein concentration is variable but ranges from 28% at the rosette stage down to 11% at the bud stage, and should be sufficient to meet the general maintenance requirements for most ruminants. Yellow starthistle appears to have the ability to sustain animals several weeks beyond annual grass "dry down" when it is abundant. Intensive grazing in late May and June using large numbers of animals for short duration can reduce plant height, canopy size, and seed production. Avoid overgrazing, however; do not allow more than half the grass forage to be removed. Grazing more than this will reduce the grasses' recovery rate and ability to shade out yellow starthistle.

Burning is best performed at the end of the rainy season when flowers first appear. Yellow starthistle should be green at this time and will require desiccated vegetation to burn. Most annual vegetation other than yellow starthistle, particularly grasses, should have dried and shed their seeds by this time. The foliage of these plants serves as a fuel source to allow a more complete burn. Burning for 2 or more consecutive years helps suppress yellow starthistle and deplete the soil seedbank. Burning can also increase the recovery and density of perennial grasses. Do not burn areas where insects have been released for biological control because fire will kill them.

Revegetation

Control practices are capable of reducing yellow starthistle populations, but in the absence of competition, starthistle will reestablish. Effective management requires that desirable plant species be encouraged or planted and managed to prevent yellow starthistle germination or growth. Species choice for revegetation will depend on the intended use of that site. Resident vegetation such as perennial bunchgrasses or wildflowers may be desirable along roadsides, abandoned pastures, or in rangelands and wildlands. In these situations, cultural, biological, or chemical methods can be used to reduce yellow starthistle while encouraging other plant species, if possible, with practices such as fertilization. Research efforts to reestablish native or introduced perennial bunchgrasses are in progress. Perennial grasses are slow to establish and may require herbicide treatments to assist yellow starthistle or annual grass control during establishment, but once well established, alternative controls such as properly timed grazing, mowing, or burning can be used effectively.

In pastures, eliminate dense stands of yellow starthistle and reseed the area with a fast-growing, competitive forage species. Although annual legumes work well for this purpose, the lack of selective herbicides makes follow-up treatments difficult. Therefore, grasses are best because selective herbicides can then be used to control yellow starthistle plants not eliminated by grass competition. In areas with scattered yellow starthistle infestations, eliminate scattered plants and overseed with a desirable species to provide enough competition to prevent yellow starthistle from reestablishing.

In all instances, choose desirable species that are well adapted to the site and not likely to become invasive themselves. Species that grow well are the best competitors.

Chemical Control

Both postemergent and preemergent herbicides are available to control starthistle along roadsides, rights-of-way, and noncrop areas. Most herbicides registered for use in rangeland and pastures are only active postemergence. Clopyralid, however, has both preemergence and postemergence activity on yellow starthistle.

Postemergent Herbicides. Postemergent herbicide treatments generally work best on seedlings. The long germination period of yellow starthistle makes control with a single application almost impossible. A treatment following the first flush of seedlings opens a site up for later flushes. Waiting until later in the rainy season to apply a postemergent herbicide allows a greater number of seedlings to be treated, but larger plants will require higher herbicide rates and may not be controlled.

- *Clopyralid* is a newly registered growth regulator herbicide for use in noncrop areas, including rangeland and pastures. Unlike the other growth regulator herbicides, it is very effective on yellow starthistle both postemergence and preemergence. The most effective timing for application is from January to February, when yellow starthistle is in the early rosette stage. Applications earlier may not provide full-season control and later applications will require higher rates. A single application at the recommended time will provide season-long control. Clopyralid is effective at rates as low as 1.5 oz a.e./acre. It is selective on many members of the sunflower family, particularly thistles, but can also injure legumes, including clovers. Most other broadleaf species and all grasses are not injured by clopyralid. There are no grazing restrictions after clopyralid use in rangelands. Clopyralid is also effective on plants in the bolting and early spiny stage, but higher rates (4 oz a.e./acre) are required. While not registered for use around the home, clopyralid does have registration for use in pastures, rangelands, rights-of-way, roadsides, and other noncrop areas.

- *2,4-D* can provide acceptable control of yellow starthistle if it is applied at the proper rate and time. Treatment in the rosette growth stage provides better control than later applications. Amine formulations are as effective as ester formulations at the small rosette growth stage, and amine formulations reduce the chance of off-target movement.

  Application rates of 0.5 to 0.75 lb a.i./acre will control small rosettes. Applications made later in the season, when rosettes are larger or after bolting has been initiated, require a higher application rate (1 to 2 lb a.i./acre) to achieve equivalent control. 2,4-D is a growth regulator and a selective herbicide that controls many other broadleaf plants, but has minimal effect on clovers and generally does not harm grasses. It has little, if any, soil activity. Drift from 2,4-D applications is common, particularly from ester formulations. Use caution when applying near sensitive vegetation or during windy or high temperature conditions. Certain formulations of 2,4-D require a restricted materials permit; generally formulations that are sold in small quantities (i.e., liquid formulations that do not exceed 1 quart and dry formulations that do not exceed 1 pound) do not require a permit.

- *Dicamba* is very effective at controlling yellow starthistle at rates as low as 0.25 lb a.i./acre. When yellow starthistle rosettes are small, about 1 to 1.5 inches across, the 0.25 lb a.i./acre rate works well, but higher rates (0.5 to 0.75 lb a.i./acre) are needed if plants are larger. Applications made in late rosette to early bolting stages have provided excellent control, although earlier treatments are better.

Dicamba is also a growth regulator and selective herbicide that controls many broadleaf plants, including clovers, but does not harm grasses. Its soil activity is very short. Like 2,4-D, it is available as both an amine and as an ester formulation. Drift from dicamba applications is common, especially from the ester formulation. Use caution when applying near sensitive vegetation. Certain formulations of dicamba require a restricted materials permit; generally formulations that are sold in small quantities (i.e., liquid formulations that do not exceed 1 quart and dry formulations that do not exceed 1 pound) do not require a permit.

- *Triclopyr* at 0.5 lb a.i./acre provides complete control of yellow starthistle seedlings. Larger plants require rates up to 1.5 lb a.i./acre. Like 2,4-D and dicamba, triclopyr is a growth regulator herbicide with little or no residual activity. It is foliar-absorbed and active on broadleaf species, including clovers, but typically does not harm grasses. Triclopyr is formulated as both an amine and ester. The ester formulation is more sensitive to drift than the amine form. Caution should be observed when using the ester formulation. This material is registered for use around the home as well as for pastures, rangelands, rights-of-way, roadsides, and other noncrop areas.

- *Glyphosate* controls yellow starthistle at 1 lb a.i./acre. Good coverage, clean water, and actively growing yellow starthistle plants are all essential for adequate control. Unlike growth regulator herbicides, glyphosate is nonselective and controls most plants, including grasses. It has no soil activity. A 1% solution of glyphosate also provides effective control and is used at this concentration for spot treatment of small patches. An application of glyphosate is a very effective method of controlling starthistle plants in the bolting, spiny, and early flowering stages at 1 to 2 lb a.i./acre. However, glyphosate will severely damage desirable perennial grasses if they are sprayed as well. Glyphosate is registered for use around the home as well as for pastures, rangelands, rights-of-way, roadsides, and other noncrop areas.

Preemergent Herbicides. Preemergent herbicides must be applied before seeds germinate to be effective. The long germination period of yellow starthistle requires that a preemergent material have a lengthy residual activity. Make applications before a rainfall, which will move the material into the soil. Because these materials adhere to soil particles, off-site movement and possible injury of susceptible plants could occur if the soil is dry and wind occurs before rain. When yellow starthistle plants have already emerged, it is possible to combine a postemergent herbicide (to control emerged plants) with a preemergent herbicide (to provide residual control of any subsequent germination) for an effective control strategy.

Chlorsulfuron and sulfometuron are preemergent herbicides that are registered for roadside and other noncrop uses. They are very effective at controlling yellow starthistle when applied at 1 to 2 oz a.i./acre. Little postemergence activity occurs on yellow starthistle with these two compounds. Best control is achieved when applications are made before weeds emerge. They may not be used in pastures, rangeland, or around the home.

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits and/or vegetables ready to be picked.

Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse the containers. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Do not pour down sink or toilet. Consult your county agricultural commissioner for correct ways of disposing of excess pesticides. Never burn pesticide containers.